The Role of Battery Electric Vehicles (BEVs) in Reducing CO_2 Emissions in Latin America and the Caribbean

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Abstract*—The transportation sector in Latin America and the Caribbean contributes 37.7% of the region's greenhouse gas (GHG) emissions, driven primarily by reliance on fossil fuels. This makes decarbonization of transportation critical for meeting global climate targets. Electric mobility (EM) is widely regarded as a viable solution to reduce emissions; however, its effectiveness depends on the carbon intensity of each country's energy matrix. While substantial progress has been made in adopting renewable energy sources in the region, gaps remain in understanding the relationship between electric mobility and emission reductions, particularly across countries with diverse energy profiles. This study aims to evaluate the role of battery electric vehicles in reducing CO_2 emissions in Latin America by conducting a systematic review of regional literature and analyzing CO_2 emissions from Battery Electric Vehicles (BEVs) and Internal Combustion Engine Vehicles (ICEVs). The methodology included a narrative systematic review following PRISMA 2020 guidelines and a comparative analysis of emissions using a comparative emissions analysis between three of the best-selling BEVs in Latin America (BYD Dolphin GS 180EV, Tesla Model 3, and BYD Seagull) and the region's best-selling gasoline vehicle (Volkswagen Golf). Emissions were calculated based on the carbon intensity of electricity generation in each country. The findings reveal significant variability in emission reductions, with countries like Paraguay, Costa Rica, Uruguay, and Brazil, which have renewable energy grids, achieving reductions exceeding 90%. In contrast, nations with fossil fuel-heavy grids, such as Cuba and the Dominican Republic, see more modest reductions, although BEVs consistently outperform gasoline vehicles in all scenarios. Key barriers identified include insufficient charging infrastructure, high upfront costs of BEVs, and limited data for smaller nations. This study highlights the importance of integrating electric mobility strategies with renewable energy investments to maximize environmental benefits. Policymakers must address infrastructure deficits and regional disparities while promoting fiscal incentives and international collaboration. These findings underscore the transformative potential of electric mobility in achieving substantial CO_2 reductions, offering a pathway for Latin America to align with global sustainability goals.

***Keywords*—battery electric vehicles, greenhouse emissions, Latin America, electro mobility, automotive engineering**

I. Introduction

Climate change is a global challenge driven by greenhouse gas (GHG) emissions from human activities, with the energy sector being one of the largest contributors [1]. This sector encompasses both electricity generation and transportation, which together account for a significant share of global emissions. In the European Union, the transportation sector generates approximately 30% of GHG emissions [2], while in Latin America and the Caribbean, this figure rises to 37.7% [3]. This highlights the need to regulate and adopt technologies that effectively reduce emissions in these sectors.

In Latin America and the Caribbean, transportation is heavily reliant on fossil fuels such as gasoline and diesel, further exacerbating GHG emissions [4]. In this context, electric mobility has emerged as a viable alternative to reduce fossil fuel dependency and associated emissions. Battery Electric Vehicles (BEVs), which do not produce direct emissions during operation, have the potential to transform the transportation sector. However, the net environmental impact of BEVs largely depends on each country's energy matrix. In nations where electricity generation relies heavily on renewable sources, such as solar, wind, and hydroelectric power, the benefits in terms of emission reductions are more significant, since these technologies do not generate emissions during the operational phase of energy production This contrasts with countries whose grids are predominantly based on fossil fuels [5].

The 2030 Agenda for Sustainable Development established Sustainable Development Goal (SDG) 13, which calls for urgent action to combat climate change by reducing GHG emissions. As a significant emitter, the transportation sector is pivotal to achieving this goal. Transitioning to cleaner technologies, such as electric mobility, aligns with these mitigation objectives and represents a crucial tool for decarbonization strategies in Latin America and the Caribbean [6].

A. Efforts in Electric Mobility in Latin America and the Caribbean

Several countries in the region have implemented policies and programs to foster the adoption of electric mobility. Key initiatives include:

Bolivia: The country inaugurated electric charging stations in cities such as El Alto and Oruro, offering free charging for one year to encourage EV adoption. Additional stations were installed in La Paz and Cochabamba to expand coverage [7].

Peru: Introduced accelerated depreciation for EVs as a fiscal incentive. The Ministry of Energy and Mines also installed charging infrastructure at government facilities and integrated fully electric buses into public transportation as part of the "Electric Distribution 4.0" project [7].

Jamaica: In partnership with the Inter-American Development Bank (IDB) and the Jamaica Public Service Foundation (JPS), launched the "eDrive" program in 2022. This initiative trains mechanics and technicians in risk management, maintenance, and repair of electric vehicles [7].

Uruguay: Developed the MOVÉS project, which includes the "TuVE" program that allows public and private institutions to test electric vehicles at no cost. Additionally, the Subite program provides financial incentives of up to

$5,000 to replace combustion vehicles with electric ones. Uruguay also set ambitious goals to electrify its public transport fleet, targeting 25% electric buses by 2025 and 100% by 2040 [7].

Central America: The "Central American Electric Route," organized by ASOMOVE with support from the Central American Bank for Economic Integration (CABEI), demonstrated the feasibility of cross-border EV travel. Covering over 1,800 km across six countries, the initiative promoted the development of a regional charging network and fiscal incentives for EV adoption [7].

Despite these advancements, it is essential to conduct a comprehensive analysis that considers not only the operational emissions of EVs but also those associated with electricity generation. This approach enables a realistic evaluation of the environmental impact of electric mobility in the region and whether it meets expectations for emission reductions.

B. Energy Matrix in Latin America and the Caribbean

The energy matrix plays a critical role in the transition toward a sustainable development model and is essential for understanding the environmental impact of electric mobility. In this context, Sustainable Development Goal (SDG) 7 emphasizes the need to ensure access to affordable, reliable, sustainable, and modern energy for all. This goal also underscores the importance of diversifying energy sources, reducing reliance on fossil fuels, and promoting renewable energy use [8].

In Latin America and the Caribbean, while progress has been made in incorporating renewable sources such as hydro, solar, and wind power, many countries still depend heavily on fossil fuels. Diversifying the energy matrix is not only essential for environmental sustainability but also critical for maximizing the benefits of electric mobility. A renewable-based energy matrix enhances the advantages of EVs by ensuring that the electricity used for charging is clean and low in GHG emissions. In table 1, it shows the sources of energy by country.

Table 1. Energy Source by Country made with data updated to 2022, 1 Hydro, 2 Gas, 3 Nuclear, 4 Wind, 5 Solar, 6 Biomass, 7 Geotherm [9]

COUNTRY	1	2	3	4	5	6	7
Mexico	20%	60%	5%	5%	10%	0%	0%
Guatemala	40%	35%	0%	10%	5%	10%	0%
Belize	50%	20%	0%	10%	10%	10%	0%
El Salvador	30%	0%	0%	10%	15%	20%	25%
Honduras	35%	30%	0%	15%	10%	10%	0%
Nicaragua	50%	20%	0%	10%	10%	10%	0%
Costa Rica	70%	10%	0%	10%	5%	5%	0%
Panama	60%	20%	0%	10%	5%	5%	0%
Cuba	30%	40%	0%	10%	10%	10%	0%
Dominican Republic	25%	50%	0%	10%	10%	5%	0%
Haití	10%	70%	0%	5%	5%	10%	0%
Puerto Rico	20%	60%	0%	10%	5%	5%	0%
Colombia	70%	20%	0%	5%	5%	0%	0%
Venezuela	60%	30%	0%	5%	5%	0%	0%
Ecuador	50%	30%	0%	10%	5%	5%	0%
Peru	40%	50%	0%	5%	5%	0%	0%
Bolivia	30%	50%	0%	10%	5%	5%	0%
Paraguay	80%	10%	0%	5%	5%	0%	0%
Chile	30%	30%	0%	15%	20%	0%	5%
Argentina	30%	50%	10%	5%	3%	2%	0%
Uruguay	40%	20%	0%	20%	10%	10%	0%
Brazil	60%	10%	0%	10%	5%	15%	0%

Under this context, this narrative systematic review aims to compare the greenhouse gas emissions of electric vehicles (EVs) and internal combustion engine vehicles (ICEVs) in Latin America and the Caribbean.

C. Scope and Limitations

For the scope and limitations delineated in this study, the authors will exclusively consider Tank-to-Wheel (TTW) emissions, thereby excluding other emission categories inherent to the complete product lifecycle. These omitted categories encompass battery production, end-of-life management (including disposal and recycling), and upstream material extraction processes, such as lithium acquisition. Consequently, the present analysis is restricted to TTW emissions; future research endeavors will necessitate the incorporation of a comprehensive Life Cycle Assessment (LCA) to evaluate the entirety of the production chain.

Indeed, the estimated carbon dioxide (CO_2) emissions for electric vehicles within the scope of this study are potentially subject to upward revision upon the inclusion of battery pack lifecycle emissions in a comprehensive analysis. As previously indicated, the extraction of raw materials requisite for battery manufacturing continues to rely, in part, on conventional energy sources.

Data reliability in several Latin American and Caribbean countries presents another constraint on this study. Consequently, the analysis excludes these nations, focusing solely on data from verifiable sources.

An additional methodological constraint pertains to the typology of vehicles analyzed within this study. The investigation was exclusively focused on compact and mid-size passenger vehicles, excluding smaller vehicle classes, motorcycles, and heavy-duty vehicles such as passenger buses. The BEV models BYD Dolphin GS 180EV, Tesla Model 3, and BYD Seagull were selected due to their status as the best-selling vehicles in this segment in Latin America [10–12]. These were compared to the Volkswagen Golf, the leading gasoline-powered vehicle in sales within the same segment in the region [13]. The selection was This selective inclusion of vehicle categories may influence the broader applicability of the findings to the entire spectrum of the transportation sector.

II. Materials and Methods

To achieve the purpose of this study, the authors considered the electric grid of each Latin American country. For this, data from the Latin American Energy Organization and its Information System (SIELAC) were consulted. This database contains information updated through 2023. It is important to note that the electric energy emission factor is determined by considering the percentage share of each type of energy source, the emission factor of each fuel, and the typical efficiency factor of thermal power plants. The applied protocol is referenced in [14].

Subsequently, the three best-selling battery electric Vehicles (BEVs) were identified, and their technical specifications were reviewed. From these specifications, the battery capacity and the range per full charge were the key data points used to calculate the emissions associated with the operation of these vehicles in each country. The equation applied is:

$$\text{Ekm} = \frac{(\text{Bc} \times \text{FEc})}{P}$$

where:

Bc = Battery capacity (kWh), obtained from the technical data sheet.

FEc = Electric generation emission factor in each country (Ton CO_2e/kWh).

P = Performance of the BEV (km per full charge).

Ekm= Emissions per kilometer traveled (Ton CO_2e/km)

Additionally, the most sold gasoline-powered vehicle in the region was identified. Based on its technical data, the emission factor per kilometer was obtained. This allowed for a comparative analysis of emissions between the BEVs and the gasoline vehicle in each country.

The percentage reduction in emissions is calculated by comparing the total emissions of the reference gasoline vehicle (Volkswagen Golf) with those of the Battery Electric Vehicles (BEVs). This reduction is estimated based on the difference between the emissions of both vehicle types, using the following equation:

$$\%\text{Emissions Reduction} = \frac{\text{Emissions of gasoline powered car} - \text{Emissions Bev}}{\text{Emissions of gasoline powered car}}$$

This approach allows for quantifying the environmental benefit of replacing a conventional gasoline vehicle with a BEV, considering the specific emissions associated with each vehicle's operation and energy source.

Additionally, a systematic review was conducted following the guidelines and considerations outlined in the PRISMA 2020 statement to ensure transparency and rigor in the review process

III. Result and Discussion

The following section presents the results of the authors' analysis, based on the energy matrix and emission factors of each country, as well as the findings from the systematic review. This combined approach aims to evaluate the role of electric mobility in reducing CO_2 emissions

A. Comparison of CO_2 Emissions between Electric Battery Vehicles and Gasoline Vehicles in Latin America

To evaluate the potential reduction in greenhouse gas emissions through the adoption of electric mobility, it was conducted a comparison between the three best-selling Battery Electric Vehicles (BEVs) in Latin America — the BYD Seagull Hatchback, BYD Dolphin GS 180 EV, and Tesla Model 3 — and the most sold gasoline-powered vehicle, the Volkswagen Golf.

The analysis focused exclusively on operational greenhouse gas emissions, considering, for BEVs, the emissions resulting from the generation of electricity used to charge their batteries, based on the specific electricity generation emission factors of each country. For the gasoline vehicle, direct fuel combustion emissions per kilometer were assessed. It is important to note that other stages of the vehicle life cycle, such as manufacturing, maintenance, and end-of-life disposal, were not included in this analysis. This approach allowed for a country-specific comparison of the emissions associated solely with the operation of both types of vehicles within the Latin American context.

According to the technical data sheets of the vehicles reviewed in this study, the BYD Seagull and the Tesla Model 3 have a similar performance in terms of energy consumption per kilometer traveled. The BYD Dolphin has less range on a fully charged battery. The specifications are shown in the following table:

Table 2. Specification per BEV's. [15–17]

	BYD DOLPHING	TESLA MODEL 3	BYD SEAGULL
Autonomy km	291	629	380
Battery Capacity kwh	44.9	75	38
Consumed Energy per Kilometer (KWh/Km)	0.154295533	0.119236884	0.1

To compare the environmental performance of these models across Latin America, we incorporated the emission factors associated with electricity generation in each country. The following table shows the summary of this indicator for each country.

Table 3. CO_2 Emissions per country by electricity generation, data taken from SIELAC

Country	Kg CO_2 eq/Kwh
Argentina	0.316
Barbados	0.591
Belize	0.553
Bolivia	0.416
Brazil	0.123
Chile	0.288
Colombia	0.164
Costa Rica	0.039
Cuba	0.642
Ecuador (Continental)	0.185
El Salvador	0.299
Grenada	0.648
Guatemala	0.419
Guyana	0.660
Haiti	0.504
Honduras	0.650
Jamaica	0.521
Mexico	0.444
Nicaragua	0.501
Panama	0.306
Paraguay	0.005
Peru	0.263
Dominican Republic	0.581
Suriname	0.336
Trinidad and Tobago	0.531
Uruguay	0.056
Venezuela	0.183

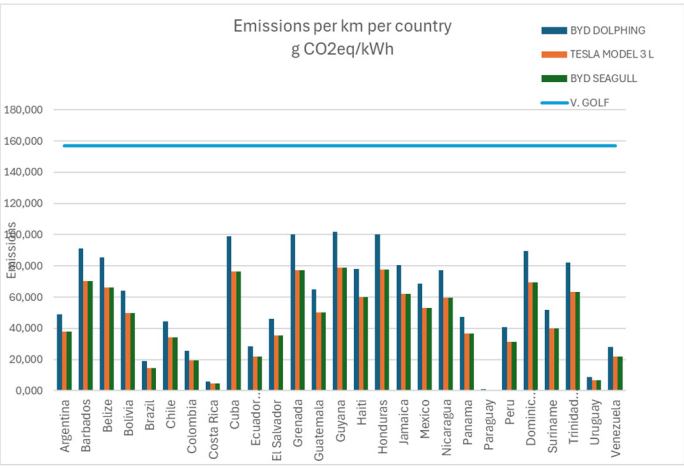

Fig. 1. Comparison of CO_2 emissions per km per country.

According to the data in the table, emissions resulting from charging the battery of the BEV's were calculated for each country. These values were then compared with the emissions from the gasoline-powered Volkswagen Golf, which were kept constant at 157.1 g of CO_2 per kilometer. Based on this analysis, the results are presented in Fig. 1, which illustrates a country-by-country comparison of the emissions per kilometer for each vehicle.

For these vehicle models, it can be observed that emissions decrease significantly across all Latin American countries, even in those with high emission factors due to electricity grids reliant on petroleum-based energy sources. Below, Fig. 2 is presented illustrating the percentage reduction in emissions for each country when using the BEV's compared to Volkswagen Golf.

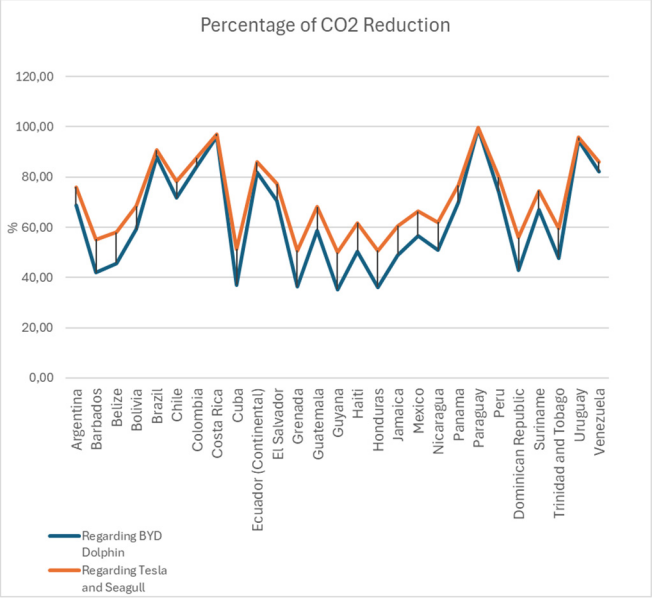

Fig. 2. Percentage of reduction of CO_2 emissions.

The analysis of emissions per kilometer for BEV's in comparison with Volkswagen Golf highlights significant differences across Latin American countries. These differences are primarily influenced by the emission factors associated with each country's electricity generation matrix. While the gasoline vehicle's emissions remain constant at 157.1g of CO_2 per kilometer, the emissions of the BEV´s vary considerably, ranging from 4.7g of CO_2 per kilometer of the Tesla Model 3 or the BYD Seagull in Paraguay, to 101.8g of CO_2 per kilometer of the BYD Dolphin in Guyana, or 98,9g CO_2 per km of the same BYD Dolphing in Cuba. These variations reflect the diverse energy profiles of the region, where emission factors span from 0.005 kg CO_2/kWh in Paraguay, followed by Costa Rica with an emission factor of 0,039kg CO_2/kWh to 0.6 kg CO_2/kWh in Guyana, similar case in Cuba. It is important to highlight that these countries are stronger dependent of oil. .

In terms of emission reduction, the data shows substantial benefits from adopting electric mobility. Countries like Costa Rica, Paraguay, Uruguay, and Brazil, which rely heavily on renewable energy sources such as hydropower, achieve reductions exceeding 90%. Paraguay stands out with the highest reduction, reaching between 99.4% to 99.6%. Conversely, countries with energy matrices dependent on fossil fuels, such as Cuba, show more modest reductions, with only 36% to 51%. decrease in emissions. Even in these cases, the electric vehicle still produces fewer emissions than the Volkswagen Golf, the gasoline vehicle reference, underlining the overall advantage of electrification.

These findings underscore the significant environmental potential of electric vehicles, but also the critical role of cleaner energy matrices in maximizing their benefits. A strong inverse relationship is observed between the carbon intensity of a country's electricity and the percentage reduction in emissions. Countries with cleaner grids see greater advantages from electric mobility, whereas those with higher reliance on fossil fuels derive smaller, though still meaningful, reductions.

It is important to note that this analysis does not fully capture the overall impact of battery electric vehicle adoption on CO_2 emissions. The study evaluates only two specific electric vehicle models and as gasoline-powered equivalent as a reference. A more comprehensive assessment would require analyzing additional vehicle models to ensure broader applicability of these findings. However, this initial review provides valuable insight into the general trend: transitioning to electric vehicles can substantially reduce emissions across Latin America, with the extent of reduction varying by country. This highlights the importance of coupling electric mobility strategies with efforts to decarbonize electricity generation to achieve maximum environmental benefits.

B. Systematic Review, Articles Overview

As mentioned in the previous section, the evaluation of a single electric vehicle model is insufficient to fully verify the role of electric mobility in reducing CO_2 emissions across Latin America. For this reason, a systematic review was conducted to complement the analysis. The findings from the reviewed literature are highlighted in this section.

1) Argentina

In Argentina, the study focuses on the gradual electrification of the public and private transportation sectors within the Buenos Aires Metropolitan Area (AMBA). Transportation accounts for 12% of the country's total greenhouse gas (GHG) emissions, with private cars emitting 5.9 million tons of CO_2 annually (at an average of 196 gCO_2/km per vehicle) and buses contributing an additional 2.2 million tons of CO_2 per year (at 1197 gCO_2/km per bus). The study projects that by 2035, complete electrification of the bus fleet would result in a 29% reduction in CO_2 emissions, avoiding 11.2 million tons of CO_2 equivalent compared to a business-as-usual (BAU) scenario. Similarly, electrifying private vehicles could achieve an 8% reduction, saving 10.06 million tons of CO_2 equivalent. These benefits are closely tied to Argentina's energy transition, which aims to reduce reliance on thermal power (64% in 2018) and achieve a balanced energy mix with 35% renewables, 28% hydroelectric, and 23% thermal energy by 2035. This shift is expected to cut the energy sector's emissions by 43%. The study also emphasizes the critical role of charging infrastructure development and policy incentives to accelerate the adoption of electric mobility in Buenos Aires and beyond [18].

2) Brazil

Brazil stands out as a leader in electric mobility due to its

highly renewable energy matrix, with over 85% of its electricity derived from non-fossil sources, including hydroelectric power (56%), wind, and solar. The country's significant capacity for renewable energy positions it as a global example for sustainable practices. Studies highlight Brazil's potential to leverage green hydrogen production using its renewable energy grid. Green hydrogen could serve as a clean energy vector for both light and heavy-duty transportation, complementing the use of electric vehicles (EVs). The findings also explore scenarios for achieving carbon neutrality in light vehicle fleets by 2050, including bioethanol-powered plug-in hybrid electric vehicles (PHEVs). This approach offers a cost-effective transition pathway with a 62% reduction in GHG emissions compared to a BAU scenario. Additionally, EVs in Brazil emit an average of 18.32 gCO_2/km, significantly lower than gasoline vehicles (170 gCO_2/km) or those powered by bioethanol (87.4 gCO_2/km). However, the total cost of ownership (TCO) for EVs remains a challenge, as it is currently 96% higher than traditional vehicles. Infrastructure remains a critical barrier, with calls for standardized charging networks and fiscal policies to incentivize both EV adoption and charging station deployment. Brazil's robust policy framework and renewable energy dominance make it a model for sustainable transportation in Latin America [19–33].

3) Chile

Chile's renewable energy matrix, comprising hydroelectric, solar, and wind power, underpins its ambitious goals for electric mobility. By 2040, it is projected that EVs will account for 60% of light vehicle sales and 33% of urban bus fleets, increasing annual electricity demand by 6,014 GWh. The environmental advantages are pronounced, with EV adoption eliminating direct emissions and significantly reducing indirect emissions due to the country's low-carbon energy generation. Specific studies demonstrate that transitioning military vehicles to electric could reduce CO_2 emissions by 74.7% using the national grid and by 96.8% when using solar photovoltaic charging stations. Additionally, transitioning conventional taxis to EVs in Santiago shows potential for emission reductions, though outcomes depend heavily on the energy source. For instance, charging with the grid results in 0.3 kg CO_2/km emissions, whereas solar charging reduces this to 0.03 kg CO_2/km. These findings highlight the importance of coupling EV adoption with renewable energy integration to maximize environmental benefits [34–36].

4) Colombia

Colombia, with a predominantly hydroelectric energy matrix, is well-positioned to benefit from electric mobility. Logistics operations using EVs have been shown to reduce CO_2 emissions by 79%, leveraging the grid's emission factor of 164.38 gCO_2/kWh. In Bogotá, a rapid EV adoption scenario could achieve an 85.6% reduction in total emissions by 2050, reducing annual emissions from 114,266 kilotons to 16,442 kilotons. Light electric vehicles for last-mile logistics present substantial environmental and economic benefits, with e-trikes emitting just 31.5 gCO_2/km and e-bikes 16.4 gCO_2/km, compared to 799.8 gCO_2/km for diesel trucks. These solutions could reduce emissions by over 95% in urban logistics. However, challenges remain, including the cost of EVs and the need for extensive charging infrastructure. Policies such as emission-based tariffs, incentives for EV purchase, and the development of renewable-powered charging networks are critical for accelerating Colombia's transition [37–44].

5) Costa Rica

Costa Rica's commitment to electric mobility aligns with its nearly 100% renewable energy grid. Public transportation, responsible for 54% of national CO_2 emissions, is a primary focus of the electrification agenda. The National Decarbonization Plan (2018-2050) mandates that 30% of public buses be zero-emission by 2035, increasing to 85% by 2050. Pilot programs, such as "MiTransporte," highlight the health and environmental benefits of electric buses, including reductions in particulate matter and fossil fuel dependency. Despite these advantages, barriers such as high initial costs and insufficient charging infrastructure hinder progress. Investments in these areas are critical for meeting Costa Rica's ambitious decarbonization goals [45].

6) Cuba

Cuba's transition to electric mobility is closely tied to its efforts to integrate renewable energy into its power grid. Currently, the country relies on fossil fuels for 63% of its energy needs, generating significant emissions. Projections indicate that a 60% renewable energy share could significantly reduce GHG emissions, particularly when combined with EV adoption. The transition to EVs would not only decrease the transport sector's dependence on imported oil but also improve air quality. However, achieving these benefits requires significant investments in renewable energy infrastructure and charging networks [46].

7) Ecuador

Ecuador, with 73% of its electricity derived from hydropower, has substantial potential for reducing transportation emissions through electrification. Studies project that transitioning to EVs could reduce emissions by 75% by 2035 under ambitious policy scenarios. Efforts to optimize charging infrastructure in cities like Quito highlight the importance of strategic planning to manage traffic flows and ensure reliable energy supply. In urban contexts, electric buses demonstrate significant efficiency gains despite challenges such as hilly terrain, which can increase energy consumption. Comprehensive policies and infrastructure investments are needed to fully realize the environmental and operational benefits of electric mobility in Ecuador [47–50].

8) Mexico

Mexico's transition to electric mobility is complicated by its reliance on a fossil-fuel-heavy energy grid, with 61% of electricity generated from gas and other non-renewable sources. Nonetheless, EVs in public transportation and taxi fleets offer significant emission reduction opportunities. For example, replacing internal combustion taxis with EVs like the Nissan Leaf could reduce operational CO_2 emissions by 22% to 27% annually. Public transit electrification in cities such as Morelia and Cuernavaca could achieve emission reductions of 50% to 90%, depending on the energy source. Integrating solar power into charging infrastructure further enhances these benefits, promoting energy independence and sustainability. However, expanding EV adoption requires

targeted investments in renewable energy and charging infrastructure [51–53].

9) Peru

The transportation sector in Peru accounts for 55% of national CO_2 emissions, with diesel vehicles being a significant contributor. Studies estimate that a 15% penetration of EVs in the market could prevent 348,437 tons of CO_2 emissions annually. In optimistic scenarios, electrification could reduce emissions by up to 20.99% by 2030. However, the country's energy grid, which still relies heavily on fossil fuels, limits the potential benefits. Policies promoting renewable energy integration and EV adoption are essential for Peru to achieve its climate targets and reduce its reliance on imported oil [54–56].

10) Uruguay

Uruguay's 95% renewable energy grid makes it an ideal candidate for electric mobility. Studies show that transitioning freight transport to electric trucks could reduce sector emissions by 42.9%, avoiding approximately 1,449 kilotons of CO_2 annually. This shift aligns with the country's broader sustainability goals and highlights the importance of leveraging clean energy for transport decarbonization [57].

11) Venezuela

In Venezuela, where hydroelectric power constitutes 70% of the energy matrix, EV adoption offers substantial emission reduction potential. EVs could cut emissions by up to 90% compared to internal combustion vehicles. However, the environmental benefits are tempered by challenges related to battery production and lifecycle emissions. Policies focused on renewable energy expansion and sustainable battery management are crucial for maximizing the impact of electric mobility [58].

12) General trends

It is evident that countries with predominantly renewable energy grids, such as Brazil, Uruguay, and Costa Rica, show the greatest benefits from the electrification of transportation. Brazil leads in the number of studies, reflecting its position as a regional benchmark in sustainable practices, while countries like Argentina and Chile also show substantial progress in the adoption of electric vehicles (EVs). Ultimately, the so-called electromobility ecosystem of these countries, mainly public policies, has driven and motivated vehicle buyers and governments (public transportation) to achieve these impactful results. Of course, much remains to be done in countries like the Dominican Republic and several smaller countries in Latin America and the Caribbean, which, to begin with, lack specific studies that demonstrate the justification and impact of electromobility. Infrastructure development, including charging stations and maintenance workshops, coupled with high acquisition costs, remain widespread challenges throughout the region, underscoring the importance of adequate and relevant public policies to encourage their adoption. These policies include subsidies, tax exemptions, and investments in charging infrastructure powered by renewable energy to improve the viability of EVs. Furthermore, greater integration of renewable energy sources into national grids is fundamental to maximize the environmental benefits of EVs. Despite these obstacles, studies consistently affirm that electric mobility is a viable and necessary strategy to achieve significant CO_2 reductions and advance sustainability goals in Latin America

IV. Conclusion

The proactive adoption of electromobility promotion strategies in Latin America and the Caribbean goes beyond merely reducing CO_2 emissions, emerging as a transformative opportunity with the potential to inspire a genuine and pragmatic energy transition globally. The region's unique geopolitical neutrality makes it a particularly attractive market for battery electric vehicle (BEV) manufacturers eager to expand their presence. The systematic review that underpins this analysis reveals a critically important finding: the significant contribution of renewable energy to the energy mix in countries such as Paraguay, Costa Rica, Uruguay, and Brazil. These nations serve as paradigmatic examples globally, demonstrating the viability of achieving emission reductions of over 90% through visionary public policies and strategic tax incentives that encourage the mass adoption of battery electric vehicles (BEVs). In contrast, countries where fossil fuels still predominate in the energy mix, such as Cuba and the Dominican Republic, are experiencing more limited reductions. In these and other countries in the region, the development and implementation of comprehensive strategies is required to effectively contribute to the fight against climate change, encouraging the adoption, acquisition, and awareness of the benefits of electromobility in the areas of transportation and urban mobility.

The comparative analysis between the BYD Seagull, BYD Dolphin and Tesla Model 3 and the Volkswagen Golf the gasoline vehicle reference illustrates the relationship between the carbon intensity of electricity generation and the effectiveness of BEVs in reducing emissions.

Despite these promising findings, significant challenges persist. The lack of widespread charging infrastructure, high upfront costs of EVs, and disparities in energy grid cleanliness hinder wide-spread adoption. Smaller nations, such as the Dominican Republic and Haiti, face additional barriers due to limited research and data availability, which complicates the development of tailored strategies. Policymakers must address these gaps by prioritizing investments in renewable energy projects, expanding charging networks, and offering fiscal incentives such as subsidies and tax breaks to encourage EV adoption.

Electric mobility aligns with broader sustainability and economic goals, offering Latin America and the Caribbean a unique opportunity to lead in global climate action. By integrating electrification efforts with energy decarbonization, the region can position itself as a model for sustainable development. However, achieving this potential requires a collaborative regional approach that leverages the strengths of renewable energy leaders while addressing disparities in infrastructure and research. Ultimately, the transition to electric vehicles provides a critical tool for achieving climate targets and advancing a more sustainable future for Latin America and the Caribbean.

Although this study presents a general review of Latin America's energy matrix, the analysis specifically considered the best-selling battery electric vehicles (BEVs) and the most sold gasoline vehicle across the region. The scope of both the systematic review and the calculations performed by the

authors is limited to the operational phase of vehicle emissions, without accounting for manufacturing, battery production, or end-of-life processes. As a recommendation, country-specific adjustments could be made by identifying the most popular gasoline and electric vehicles in each nation and applying the same methodology to estimate more precise emission reductions. Nevertheless, this document offers a comprehensive and robust overview of the current landscape of electric mobility in Latin America and the Caribbean, serving as a solid foundation for further research and policymaking in the region.

This study solely assessed tank-to-wheel (TTW) emissions, omitting battery lifecycle and material extraction impacts. Consequently, EV CO_2 emissions may be underestimated. Data reliability limited the analysis to certain Latin American and Caribbean nations. Furthermore, the vehicle scope was restricted to compact and mid-size passenger cars, potentially affecting the generalizability of the findings across the broader transportation sector.

Future research could broaden the analysis by integrating a Life Cycle Assessment (LCA) to quantify the full emissions footprint of electromobility, encompassing raw material extraction to battery end-of-life. Given data constraints in parts of Latin America and the Caribbean, future endeavors should prioritize enhancing the collection and verification of emissions and energy consumption data across the region. Furthermore, expanding the study's scope to encompass other vehicle categories, such as motorcycles, light and heavy commercial vehicles, and electrified public transport (buses), would yield a more holistic understanding of electromobility's potential within the transportation sector. Lastly, future investigations could explore the impact of varying electricity generation scenarios (energy mix) on the actual emissions reductions achieved through electromobility adoption in the diverse national contexts of the region

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Author A was responsible for structuring and drafting the manuscript, ensuring the coherence and organization of the content. Author C originally proposed the research idea and has extensive experience working on the topic, providing the conceptual foundation and background knowledge for the study. Author B contributed significantly to the data collection, analysis, and critical revision of the manuscript. All authors participated in the interpretation of the results, contributed to the final version of the article, and approved it for publication.

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