White Paper **on Sustainable Mobility**

in Latin America
and the Caribbean
2025

olade

ORGANIZACIÓN LATINOAMERICANA DE ENERGÍA | LATIN AMERICAN ENERGY ORGANIZATION | ORGANIZAÇÃO LATINO-AMERICANA DE ENERGIA | ORGANISATION LATINO-AMERICAINE D'ENERGIE

White Paper on Sustainable Mobility in Latin America and the Caribbean 2025

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Support provided by:

Chilean Sustainable Transport Strategy (CLETS) – Latin American Association of Automotive Distributors (ALADDA) – Latin American Fuel Entrepreneurs Commission (CLAEC) – Clean Energy of Costa Rica (ELCO) – Institute of the Americas – United Nations Environment Programme (UNEP) – University of Santiago de Chile, Faculty of Engineering, Department of Electrical Engineering – REDTRANSPORTE CHILE – Chile Sustainability Agency.

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First Edition – September 2025

ISBN: 978-9978-70-162-1

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Sustainable Transportation: A Pillar of Energy Transitions

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Sustainable mobility is one of the strategic pillars of the energy transition in Latin America and the Caribbean (LAC). The transportation sector, which represents one of the largest energy demands in the region and is responsible for a significant share of greenhouse gas emissions, underscores the urgent need for profound transformation. Rapid urbanization, economic dynamism, and the sustained increase in demand for land, air, maritime, and river transportation reinforce the challenge of steering this sector toward a cleaner, more resilient model aligned with global climate commitments.

In this context, the development of sustainable mobility offers unique opportunities to contribute to the decarbonization of regional economies, foster technological innovation, drive green job creation, and improve the quality of life in our societies. The abundance of renewable resources in LAC, reflected in one of the cleanest energy matrices in the world, creates particularly favorable conditions to advance the transition in transportation. This is further reinforced by an expanding urban market and a population increasingly aware of environmental challenges, which enables the accelerated adoption of innovative solutions.

Within this framework, OLADE presents the first edition of the White Paper on Sustainable Mobility in Latin America and the Caribbean, conceived as an analytical and decision-support tool for governments, the private sector, multilateral organizations, and academia. Its purpose is to provide a comprehensive vision of the progress, barriers, and prospects of sustainable mobility, placing the energy dimension at the core of change.

The document addresses electromobility and its impact in the region, including the evolution of the electric vehicle fleet, charging infrastructure, and current regulatory frameworks. It highlights the exponential growth of the light electric vehicle fleet, which increased from nascent numbers in 2020 to over 440,000 units by 2024, driven by a combination of public policies, technological advances, and improved competitiveness of electric vehicles. This trend reflects the close relationship between electric mobility and the growing penetration of renewable energy into the region's power grids.

However, the scope of sustainable mobility in LAC goes beyond electromobility. In the aviation sector, the introduction of Sustainable Aviation Fuels (SAF) is emerging as a key tool to reduce the carbon footprint, considering that international aviation remains one of the hardest transport segments to decarbonize. Likewise, advanced biofuels represent a strategic alternative to diversify energy sources and harness the biomass potential available in the region.

Maritime and river transport, essential for territorial integration and international trade, are also priority areas in this discussion. The adoption of alternative fuels is a necessary step to align this segment with sustainability objectives. The inclusion of river and maritime transportation in the White Paper reflects the importance of considering all modes of transport in regional energy and climate planning.

The sustainable mobility agenda also includes the analysis of energy carriers such as green hydrogen, which could play a decisive role in high-energy-demand segments like heavy transport, aviation, and long-distance shipping. Similarly, the development of lithium batteries and the availability of critical minerals reaffirm LAC's strategic importance in the global value chain of future mobility.

The White Paper on Sustainable Mobility in LAC provides a detailed overview of regulatory progress and public policy initiatives implemented across the region. These efforts include tax incentives, subsidies for electric vehicle purchases, preferential electricity tariffs, and regulations promoting the interoperability of charging infrastructure. Nonetheless, challenges remain in terms of urban and energy planning, technological standardization, and the need for sustainable financing to accelerate investments.

This editorial effort reflects OLADE's conviction that sustainable mobility is not merely a sectoral policy, but a structural component of the regional energy transition. Progress in electromobility, the deployment of SAF, the strengthening of biofuels, and the modernization of maritime and river transportation must be seen as part of a comprehensive process, where technological innovation, regional cooperation, and inclusive access to clean energy solutions are top priorities.

I would like to highlight and thank the active participation of Member States' governments, academic institutions, the private sector, and multilateral organizations that contributed to the development of this document. Their knowledge, commitment, and vision have been decisive in making this first edition a regional benchmark and a foundation for strengthening dialogue and sharing experiences.

The challenge is considerable, but so is the opportunity. Latin America and the Caribbean have the energy conditions and resources needed to lead the transformation toward sustainable, inclusive, and competitive mobility. This White Paper seeks to support that path, with the firm conviction that the future of transportation in the region will inevitably be cleaner, more efficient, and more resilient.

Our Contribution to Sustainable Mobility

Fitzgerald Cantero Piali
Studies, Projects and Information Director
OLADE

The way we move defines the quality of life in our cities. With the accelerated growth of the urban population - a trend that will continue in the coming years - mobility has become a central challenge for governments, territorial planning and development strategies.

Expanding cities require public policies that ensure livability and well-being. To achieve this, mobility must be sustainable: transport systems that shorten travel times, are accessible and comfortable for people, and at the same time environmentally friendly.

Strategies vary according to the reality of each country and the availability of energy resources. Some are committed to electric mobility, others to biofuels, hydrogen or a combination of alternatives. What is common to all is the priority in decarbonising a key sector.

In Latin America and the Caribbean, several countries have high electricity generation from renewable sources, which represents a strategic opportunity to boost electric mobility. In contrast, those whose matrix remains heavily dependent on oil face greater difficulties for this transition. Substituting imported fossil fuels not only contributes to the environment but also reduces exposure to international price volatility, with positive effects across the economy.

Understanding the characteristics, advantages and challenges of sustainable mobility is therefore essential. At OLADE, we embrace this commitment. In 2024, we released the first Electric Mobility Monitor, with semi-annual updates, and today we take another step forward with this first edition of the White Paper on Sustainable Mobility.

Our goal is for this material to become a reference tool for governments, the private sector, academia, and institutions engaged in all forms of mobility. We have gathered key information to enhance public policies: progress achieved, pending goals, charging infrastructure, battery development, training programs, and best practices to extend the lifespan of electric vehicles.

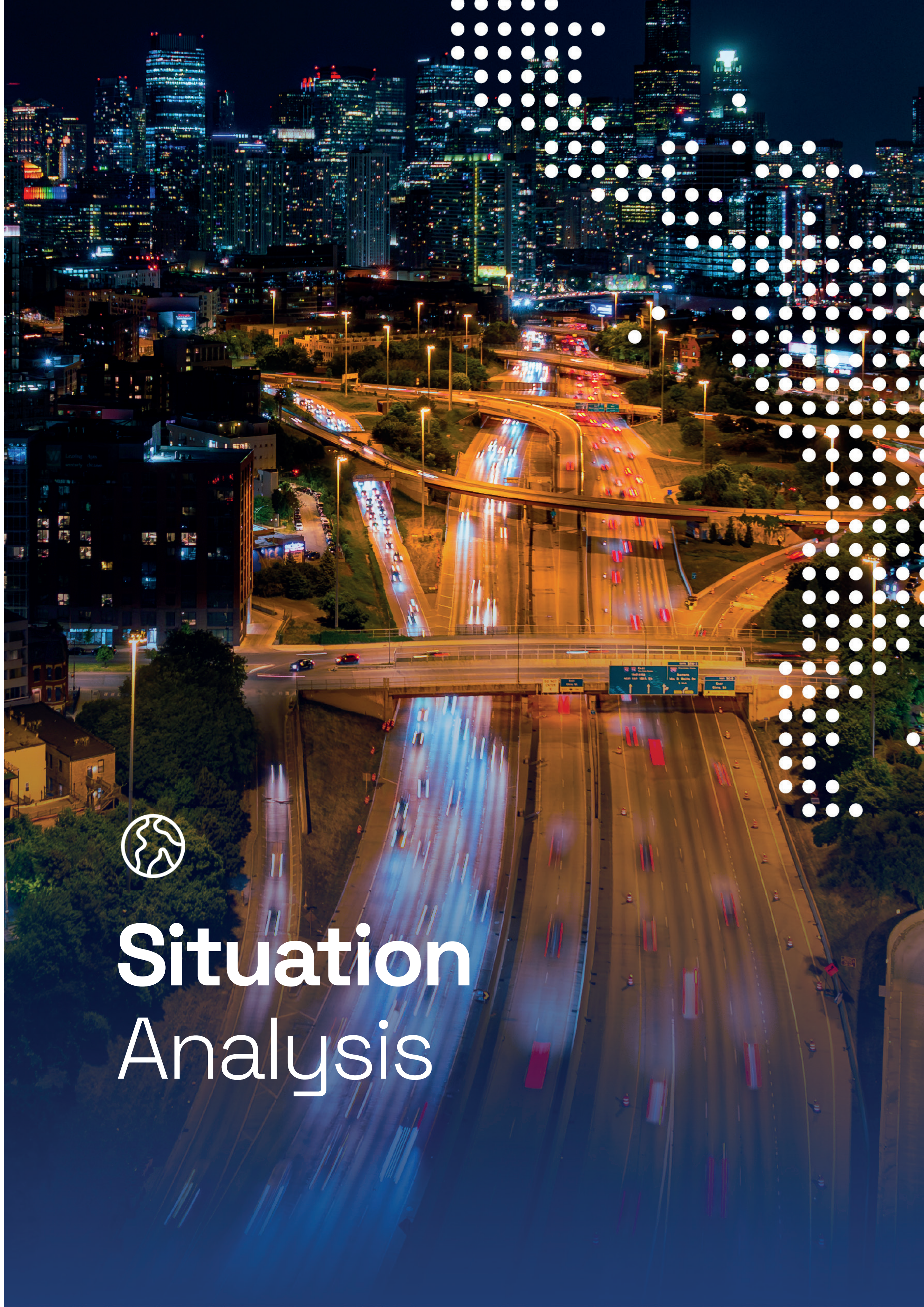
Sustainable mobility - and in particular electric mobility - brings immediate environmental benefits: reduction of CO_2 emissions, improvement in air quality and reduction of noise pollution that affects our cities.

This book also examines the geopolitical dimension of the transition. Our region possesses critical minerals essential for the development of new technologies. This represents a unique opportunity to move from the mere export of raw materials to generating added value through the manufacturing and assembly of strategic components.

An additional challenge is regional integration. The development of electric corridors that cross borders, along with the digitalization of charging points, is essential for planning trips, ensuring interoperability, and facilitating payments in any country.

This White Paper is, therefore, our contribution at this moment to the debate and action on sustainable mobility. We know that new challenges lie ahead, and we will face them with enthusiasm and conviction, in partnership with all the stakeholders who make the transformation of mobility in Latin America and the Caribbean possible every day.

In the end, we wish this book to be useful, to inspire new initiatives, and to help strengthen a sector that is crucial for our economies and for the lives of those of us living in the region. Our sincere gratitude to all those who made it possible.



Situation Analysis

Sustainable Mobility in Latin America and the Caribbean

In recent decades, sustainable mobility has established itself as a key component in international strategies to combat climate change and achieve sustainable development goals. This is likely due to the fact that the transport sector is a major contributor to greenhouse gas (GHG) emissions globally, making it an area of opportunity to deliver clearer, high-impact solutions. In Latin America and the Caribbean (LAC), the transport sector is also the main generator of CO2 by combustion with 37.7% of the total, followed in importance by the industrial sector with 28.2% and the residential sector with 13.6% (UNDP, 2024).

This context has prompted countries to accelerate their energy transition and adopt comprehensive strategies to reduce polluting emissions associated with transport. In the region, 27 of the 33 countries have defined the transport sector as a priority to achieve the emission reduction targets in the first edition of their Nationally Determined Contributions (NDCs), and most have Long-Term National Strategies (LTS) (UNEP, 2021).

On the other hand, the electric vehicle market in Latin America and the Caribbean is expanding rapidly, driven by public policies, financial incentives and greater social and environmental awareness. According to recent data from the International Energy Agency, the share of electric vehicles in the regional market reached approximately 4% of total sales in 2024, reflecting remarkable growth over previous years.

Brazil leads this trend in absolute terms, with almost 125,000 electric vehicles sold in 2024, more than twice as many as in 2023. However, other countries show an even higher penetration in relative terms, particularly highlighting Costa Rica with a sales share close to 15%, Uruguay with 13% and Colombia with approximately 7.5% (IEA, 2025).

In terms of population, the countries with the highest number of light electric vehicles per capita as of December 2024 are Uruguay and Costa Rica, Brazil, Guatemala and Mexico (OLADE, 2025). These numbers indicate not only an emerging market with rapid growth, but also the positive impact of specific policy measures such as tax incentives, tax exemptions and direct subsidies for the purchase of electric vehicles.

Regarding public transport, as of December 2024 the region had an approximate fleet of 6,700 units, which meant a 32% increase compared to the end of 2023. The fleet grew substantially since 2017 with an average growth rate of 33.5% per year. This growth was initially driven by the incorporation of electric buses in Chile and Colombia, followed by Brazil and Mexico (OLADE, 2025; ICCT, 2025), while other countries such as Belize, Costa Rica and Paraguay have lagged behind in the electrification of this segment.

Key Factors of the Situation

Economic

Several countries in Latin America and the Caribbean have implemented specific financial policies to encourage the adoption of electric vehicles. These include direct purchase subsidies, preferential credits, tax exemptions, vehicle tax discounts, and removal of driving restrictions. Costa Rica, for example, offers exemptions from taxes on electric vehicles, including VAT, selective consumption tax and tariff duties (Government of Costa Rica, 2022).

In Uruguay, tax benefits are granted, reduction of taxes on the import of electric vehicles (Ministry of Industry, Energy and Mining, 2021). In Brazil, certain states apply reductions in the IPVA (Motor Vehicle Property Tax) and green financing lines are promoted (ICCT, 2022). These incentives have contributed significantly to the growth of the EV market in those countries.

However, there are still significant economic barriers, including the high initial costs of acquiring electric vehicles, the limited public financial resources available to support large investments in the electrification of public transport and charging infrastructure, and the lack of specific financial instruments aimed at the private sector to incentivize investment in large-scale electric mobility.

Political and Institutional

A determining factor for the advancement of sustainable mobility in the region is the stability and continuity of public policies. Currently, there is a political and institutional fragmentation that limits the scope and continuity of strategic initiatives for sustainable mobility. In Latin America and the Caribbean, it is common to observe that electric and sustainable mobility policies are exposed to political cycles and government changes, which hinders the stable implementation of long-term strategies.

Additionally, there is still no unified regional vision to address the transition to electric mobility, although subregional initiatives such as the Caribbean Community Regional Working Group on Electric Vehicles (CARICOM) and the Technical Group on Electromobility promoted by the Central American Integration System (SICA) were identified that seek to share experiences, lessons learned and best practices on the use and performance of electric vehicles; and advise the Council of Energy Ministers on matters related to electromobility, promoting the transition to this technology and cleaner and more sustainable mobility (UNEP, 2021; SICA, 2023).

Social and Territorial

Existing socio-economic inequality in Latin America and the Caribbean is a key challenge for the equitable adoption of sustainable mobility. The concentration of charging infrastructure and electric vehicles in major cities generates territorial gaps, limiting access to clean technologies in rural areas or intermediate cities. In addition, the high initial cost of these technologies restricts their accessibility, generating resistance to change.

This context implies the need to address policies of social inclusion, just transition and equitable access to new technologies, ensuring that transformations in mobility are perceived as collective benefits and not exclusive privileges. It also involves reinforcing citizen awareness of the environmental, economic and social benefits derived from cleaner and more sustainable mobility.

External

External factors also have a decisive influence on the current situation. Latin America and the Caribbean face challenges related to technological and economic dependence on external markets, mainly China, which currently dominates more than 70% of the global supply chain of electric batteries (IEA, 2022). This situation presents considerable risks, as it could further deepen Latin America's traditional role as an exporter of raw materials without sufficient local added value. Given this, it is strategic for the region to promote regional policies that promote not only the diversification of technological suppliers but also the endogenous development of its own industrial capacities, strengthening its technological autonomy and reducing vulnerability to global market fluctuations.

To achieve effective sustainable mobility in Latin America and the Caribbean, it is essential to have integrated, coordinated and consistent public policies in the long term. A robust regional strategy must go beyond isolated national efforts and include trade agreements that boost regional production of electric vehicles, batteries, and key components. This would make it possible to take advantage of the region's strategic resources and generate local added value.

In this sense, a key component would be to establish regional trade agreements with specific quotas for electric vehicles, similar to the Economic Complementation Agreement No. 14 (ACE No. 14) between Argentina and Brazil. It would also be important to implement preferential tariff instruments that encourage regional manufacturing of critical components. Another essential pillar is the development of charging infrastructure. To advance e-mobility, an integrated regional plan is required that prioritizes strategic fast-charging corridors, connecting key cities and major transportation routes. This should be accompanied by unified technical standards that ensure interoperability between neighbouring countries.

The transition to sustainable mobility also requires an educational strategy and the development of technical skills. The region needs specialized training centers in electric mobility linked to universities, technical institutes and the private sector. These centres should foster regional technical cooperation and promote the exchange of experience and know-how.

From a social perspective, it is necessary to ensure that this technological transformation is carried out in a fair and inclusive way. The transition cannot leave behind traditional transport workers or communities directly impacted by the extraction of critical minerals. Public policies are required that offer job training and retraining opportunities, as well as redistribution mechanisms that ensure tangible benefits for affected communities. This just transition approach must be transversal in sustainable mobility projects.

Financing and investment also play a decisive role in the viability of this strategy, a viable alternative would be to foster public-private partnerships (PPPs) to mobilize capital towards key projects, especially in infrastructure, local production and technological development. In addition, the creation of specific regional funds for sustainable mobility would make it possible to channel international climate financing resources, such as those from the Green Climate Fund.

Finally, a successful transition requires the creation of multi-stakeholder dialogue spaces that include governments, the private sector, academia, civil society organizations and local communities to legitimize decisions and ensure their sustainability over time.

Many of these elements - political, technical, social and financial - will be developed in greater depth throughout this first edition of the White Paper in order to offer a comprehensive strategic framework to move towards sustainable and fair mobility in Latin America and the Caribbean.

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Sustainable Mobility in the Rest of the World: the United States, Europe and China

Currently, the United States, Europe and China represent the three most influential technological and commercial poles in the global development of sustainable mobility.

The United States had funneled approximately USD 369 billion through the 2022 Inflation Reduction Act (IRA) to boost clean energy, electrification of transportation, and domestic lithium battery production. However, as of the change of management in January 2025, the Unleashing American Energyorder was issued, which suspended all outstanding IRA funds and revoked key programs in sustainable mobility, including charging infrastructure for electric vehicles (Economic Policy Institute, 2025). The current administration has focused on pushing legislation like the One Big Beautiful Bill of July 2025, which phases out tax incentives for electric vehicles, charging infrastructure, and clean energy ahead of schedule. While the IRA remains in place, its implementation is on hold, reorienting the federal agenda toward fossil fuels and traditional energy policies.

At the state level, California has maintained its zero-emissions mandate for 2035, which prohibits the sale of new internal combustion vehicles from that year. In addition, it has implemented support measures such as incentives for the purchase of electric vehicles and the creation of programs such as the federal tax credit, the Clean Car Reimbursement Project and Clean Fuel Rewards. In addition to this, California has created incentive programs for low-income buyers who have the requirements to ensure that the most vulnerable populations are being supported, including: the Clean Car Assistance Program and the Clean Cars 4 All (California Air Resources Board, n.d.).

In addition to its regulatory policies, California also plays a strategic role in the e-mobility value chain due to its industrial capacity. In the State, Tesla's Fremont plant is located, which is considered the largest automotive factory in the United States. According to the Tesla Impact Report 2022 (Tesla, 2023), this plant assembled about 560,000 vehicles in that year, generating an estimated economic impact of more than USD 16.6 billion for the State and directly employing more than 22,000 people.

With regard to charging infrastructure, State Assembly Law 2127 named the California Energy Commission (CEC) as the entity in charge of evaluating the charging infrastructure necessary to achieve the ambitious electrification goals set by the State. Under this mandate, the CEC published in July 2021, the first assessment of the state of the charging infrastructure, which determined that, to support 8 million light electric vehicles and 180,000 medium and heavy electric vehicles in 2030 -according to its objectives-, the State would need approximately 1.2 million and 157,000 chargers respectively. Given this scenario, the CEC developed a tool called EVSE Deployment and Grid Evaluation (EDGE), designed to identify suitable locations to install charging infrastructure based on the available network capacity and the expected energy demand according to the projections made (CEC, 2025).

The above is just one example of how, despite the disincentive at the federal level, it is possible to move towards decarbonization from subnational governments. However, it is important to note that California has the financial capacity to lead this transition. In 2024, its Gross Domestic Product (GDP) was approximately USD 4.1 trillion, positioning the State as the fourth largest economy in the world, surpassing Japan and behind the economies of the United States, China and Germany (Office of the Governor of California, 2025). This structural and productive capacity allows it not only to resist what is happening at the national level, but also to position itself as a global player in this transition.

In Europe, sustainable mobility has been structured under the European Green Deal. In this, the European Union has set ambitious goals such as a ban on the sale of combustion vehicles from 2035 - aligned with California state policies - and the mandatory deployment of charging stations every 60 km on main roads (European Commission, 2020). However, this Green Deal is not limited to setting market goals or scaling associated infrastructure as in the case of California, but also has a cross-cutting approach that includes social justice, circular economy and just labor transition.

The European Green Deal has two initiatives that include this comprehensive approach: the Fit for 55 initiative and NextGenerationEU. The first is the one that sets legislative policies, including the target of reducing greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, and the electrification targets mentioned above. While the NextGenerationEU is an initiative that seeks to accelerate the green and digital transition, allocating at least 37% of resources to climate objectives. Currently, many Member States have used these funds to deploy charging infrastructure, modernize public transport, subsidise the procurement of electric vehicles and boost the battery and components industry through the Important Projects of Common European Interest (IPEI) (European Commission, 2021; European Parliament, 2023).

In terms of its international policy, the EU has adopted a comprehensive strategy to boost sustainable mobility. Through the Global Gateway, for example, the EU is driving an international investment strategy in clean transport, energy and digital infrastructure, aimed at mobilising up to 300 billion euros between 2021 and 2027 (European Commission, 2021). Under this framework, the EU has promoted bi-regional cooperation as a vehicle to establish resilient value chains, drive the just energy transition and strengthen joint regulatory frameworks.

An example of this cooperation is the memorandum of understanding signed in May 2025 between the EU and OLADE under which the EU enters as a Permanent Observer within the organization. This agreement strengthens the institutional links between both regions and allows the EU to participate in key technical and political spaces for regional energy development. In addition, it facilitates the exchange of experiences and promotes a platform to align standards, accelerate sustainable mobility projects and promote strategic investments in infrastructure and local capacities (OLADE, 2025).

While Europe is committed to a model of governance based on cooperation and the principles of just energy transition, China, on the other hand, has consolidated its global leadership through a strategy focused on supply chain control, vertical integration and strong state intervention that has driven a large part of the global adoption of electric vehicles. In 2023, approximately 60% of all new registrations in that year were in China, and IEA projections indicate that by 2030 this share will reach close to 80% of the local market. China not only dominates the production and sale of these vehicles in its market, but is also leading global exports: in 2024, it exported around 40% of the world total (IEA, 2025).

These advances respond to internal industrial policies such as Made in China 2025, which was launched in 2015. This policy has been instrumental in positioning the country as a leader in the electric vehicle industry. It defines these vehicles, lithium batteries, and associated technologies, as priority sectors for technological self-sufficiency and global competitiveness (Kania, 2019). For those countries that have a significant automotive sector, this can pose a threat to their economies, in fact, a report by the European Council on Foreign Relations warns that the industrial heart of Germany and central Europe is at risk in the face of a "China Shock" where Chinese companies expand within the EU to avoid tariffs and could even replace local industrial networks, especially within the automotive sector (ECFR, 2025).

In addition to its industrial dominance, China also controls a significant portion of the global supply of critical minerals needed for the manufacture of electric vehicles and batteries. According to the International Energy Agency (2024), China refines approximately 90% of rare earths and more than 60% of lithium, cobalt and graphite globally. This control has allowed it to ensure the resilience of its internal value chain, reduce its dependence on external suppliers and exert a strategic influence on the global market for clean technologies.

For Latin America and the Caribbean, China's rise as an exporting power represents a strategic window of opportunity, as it can provide availability of more affordable models, especially in segments of public fleets, commercial transport and private vehicles. In fact, a large part of the electric vehicles currently entering the Latin American market use the GB/T technology standard developed by the government of China. This situation not only reduces the costs of entry to the end user, but also favors the consolidation of the Chinese standard in the region. This can have long-term implications in terms of charging infrastructure interoperability and technology dependency.

In short, the landscape of sustainable mobility in the three most relevant technology poles is diverse and constantly changing. The United States demonstrates how subnational governments can sustain and expand sustainable mobility policies even as federal support declines. Europe stands out for its comprehensive strategy that combines internal climate goals with a foreign policy that promotes cooperation and the construction of sustainable value chains respecting human rights. And China stands out for its industrial leadership driven by strong state planning and strategic control of key inputs for the energy transition. These three models present diverse routes that Latin America and the Caribbean can critically observe to build sustainable mobility adapted to their own social, institutional and productive realities.

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Current Events in LAC regarding Sustainable Movility

Introduction

Over the last four years, the light electric vehicle fleet in Latin America and the Caribbean (LAC) has experienced an exponential growth trajectory. On average, the number of units has doubled annually, reaching nearly 444,071 units in circulation by the end of 2024. This figure represents a growth of more than 25 times compared to 2020 and nearly tripling between 2023 and 2024.

This rapid growth is driven—among other factors—by the implementation of public policies in LAC countries, aimed to achieve the decarbonization targets of their economies and energy systems, in line with their international climate change mitigation commitments established in their Nationally Determined Contributions (NDCs), of which approximately 75% identify transport as an important source of GHG emission reductions, and three NDCs set targets for reducing GHG emissions in transport.

The development of electromobility is closely linked to improvements of the renewability index of the electricity generation matrix in most countries of the region, largely driven by the significant penetration of non-conventional clean generation technologies such as wind and solar photovoltaic. In addition, advances in electric vehicle manufacturing technologies, increases in supply of manufacturers and the decline in battery cost, have made the acquisition of this type of vehicle increasingly competitive compared to combustion cars with similar performance. Other measures—such as the improvement of charging infrastructure and the enactment of incentive laws across Latin America and the Caribbean—have helped to mitigate some of the gaps and challenges that still exist in order to progress toward sustainable mobility.

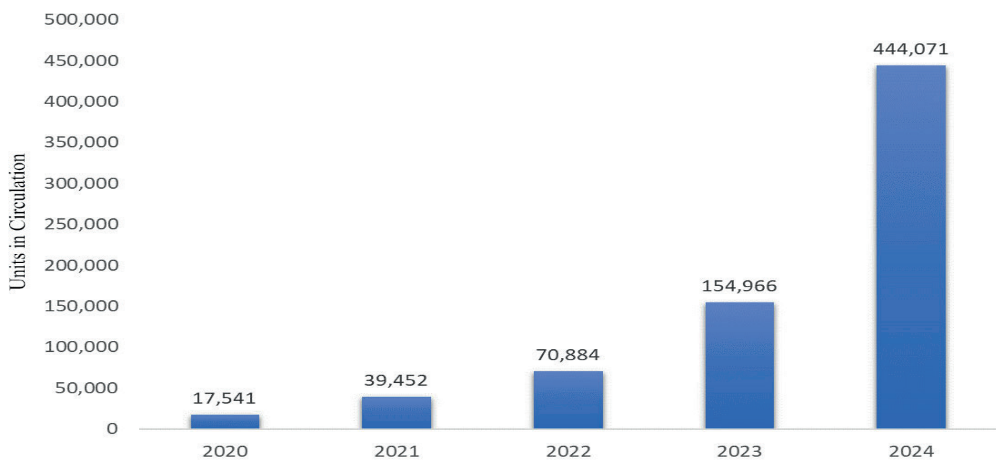
In terms of regulation, most countries have established regulatory frameworks that promote electric mobility with varying degrees of progress, which indicates that there are notable successful cases whose experiences could be replicated in other countries, representing significant potential for regional advancement. The analysis shows that one of the challenges identified in the region is the charging infrastructure, particularly regarding interoperability through the standardization of vehicle/grid communication, which remain incipient. In addition, it is also observed that in most of the countries analyzed offers incentives through subsidies for the purchase of electric vehicles and import tax reduction exemptions, while approximately 40% have preferential electricity tariffs.

Statistical data on electromobility in LAC

Light electrified vehicle fleet in Latin America and the Caribbean

In line with global trends, the incorporation of electrified vehicles—particularly BEVs and PHEVs—into the light vehicle fleet in the LAC region has grown at an exponential rate in recent years, nearly tripling between 2023 and 2024. By the end of 2024, the fleet reached 444,071 registered units of this type of vehicle, reaching a 0.3% of the total size of the region's light vehicle fleet (Figure 1).

Figure 1. Evolution of the electrified light vehicle fleet 2020 – 2024

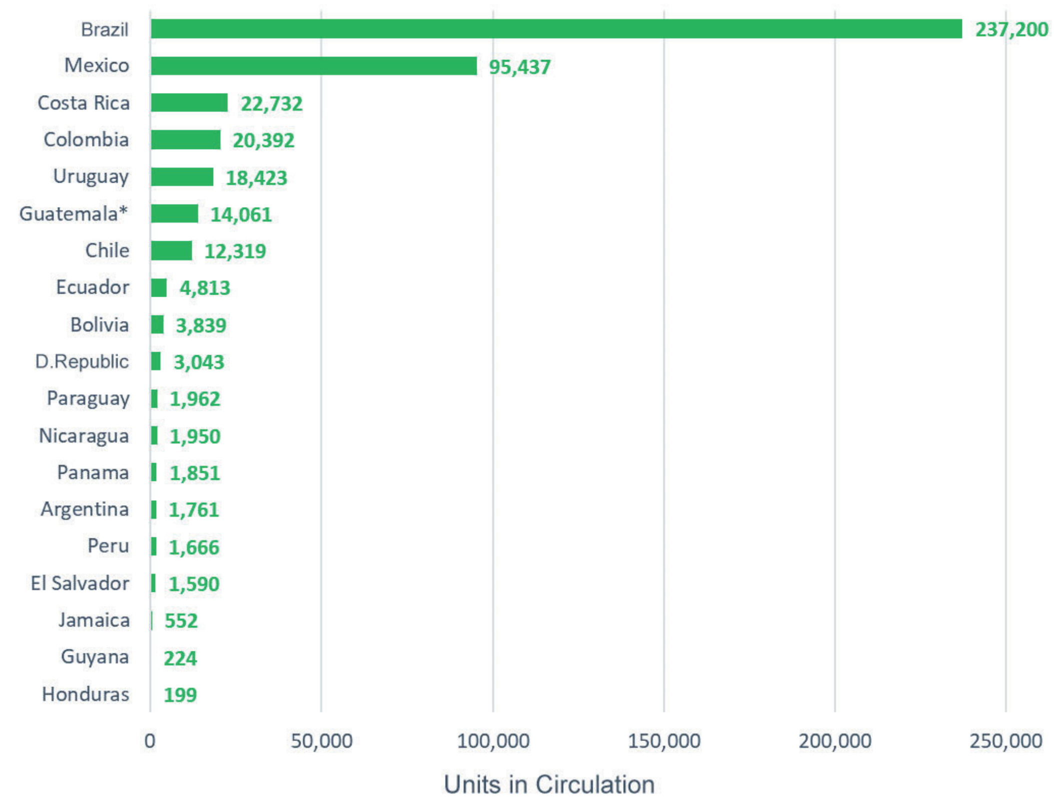


Source: Author's elaboration based on information from national statistics

Ranking of LAC countries by size of their light electric vehicle fleet

As of December 2024, Brazil leads the region with the highest number of electrified light vehicles, reaching 237,200 units—which represents more than 50% of the total number of this type of vehicles circulating in LAC at that date. Followed by Mexico, with 95,437 units, and then by Costa Rica, Colombia and Uruguay with amounts close to 20,000 units (Figure 2).

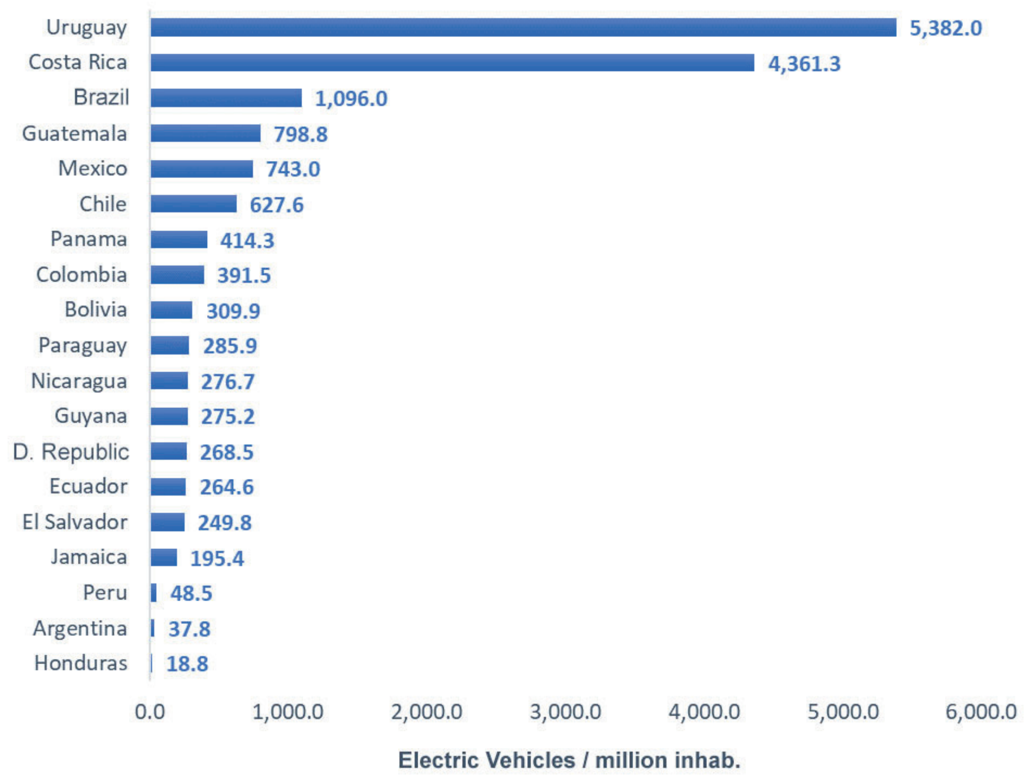
Figure 2. Ranking of the countries with the highest number of light electric vehicles as of December 2024.



(*) The data for Guatemala corresponds to electric vehicles plus hybrids
Source: Author's elaboration based on information from national statistics

In terms of population, the countries with the highest number of light electric vehicles per capita as of December 2024 are Uruguay, Costa Rica, Brazil, Guatemala, and Mexico (Figure 3).

Figure 3. Ranking of the countries with the highest relative number of light electric vehicles, in relation to their population as of December 2024



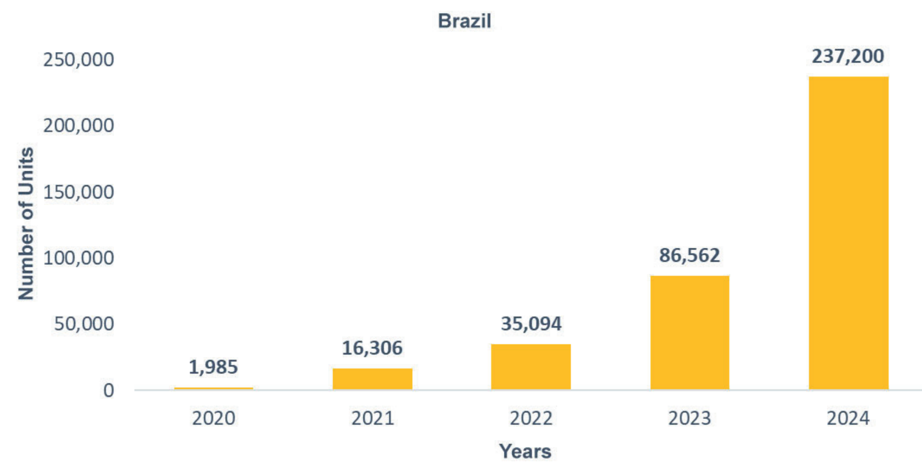
Source: Author's elaboration based on information from national statistics

Evolution of the light electrified vehicle fleet in the 10 LAC countries with the most significant presence of electromobility

Brazil

Brazil has consolidated its position as the largest electric vehicle market, with the number of units in circulation increasing by 119 times over the past 4 years. In addition, some international manufacturers of this type of vehicle—particularly Chinese companies such as BYD—have installed their production plants in this country.

Figure 4. Evolution of the electrified light vehicle fleet in Brazil 2020-2024

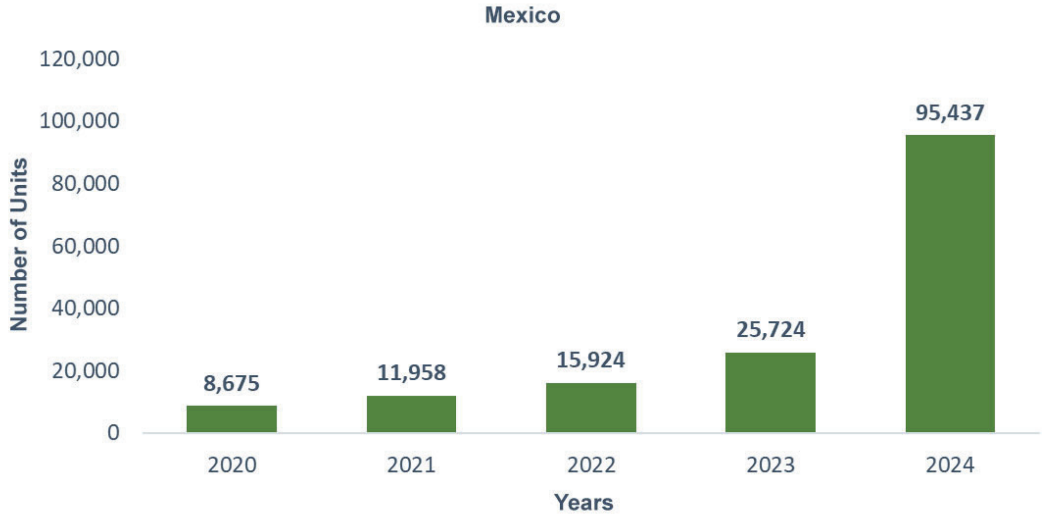


Source: Author's elaboration based on information from national statistics

Mexico

In Mexico, the size of the electrified light vehicle fleet has grown sharply, particularly between 2023 and 2024 with a growth of 271%—nearly tripling its size (Figure 5). This performance positions Mexico as the second most important market for this type of vehicle in LAC. Moreover, the country's robust vehicle manufacturing capacity enables it to venture into the production of electric cars, not only to supply the national market but also to export to regional and extra-regional markets.

Figure 5. Evolution of the electrified light vehicle fleet in Mexico 2020-2024

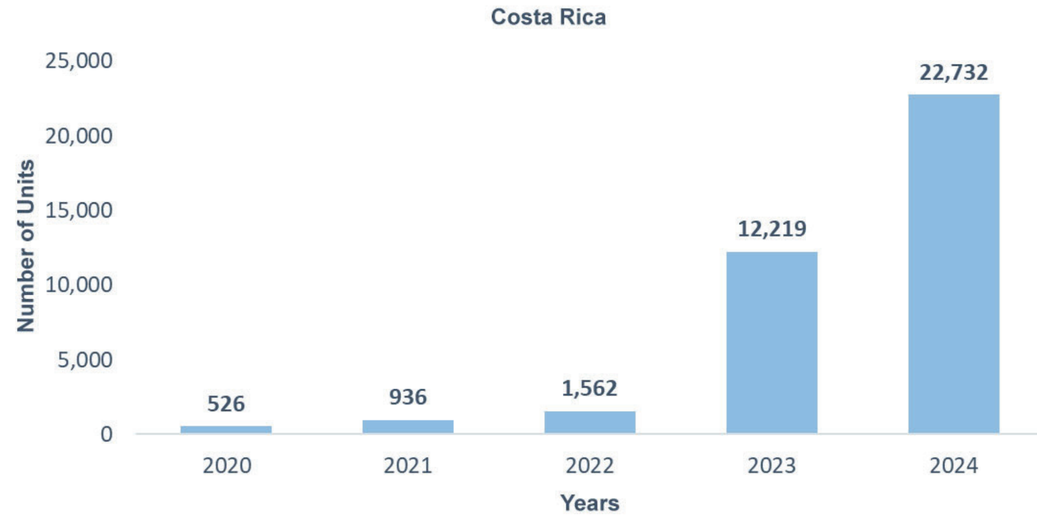


Source: Author's elaboration based on information from national statistics.

Costa Rica

Despite its small territorial size and low population, Costa Rica ranked third in the LAC region in 2024 in terms of the number of electrified vehicles in circulation, with rapid growth in sales in this sector, mainly in 2023 and 2024, where the growth of the total units in circulation was 682% and 86% respectively. This expansion has been driven by a combination of tax incentives, market competitiveness and a large expansion of the charging infrastructure. Nevertheless, by 2025, an increase in VAT and import taxes on this type of vehicle could slow down future sales.

Figure 6. Evolution of the electrified light vehicle fleet in Costa Rica 2020-2024



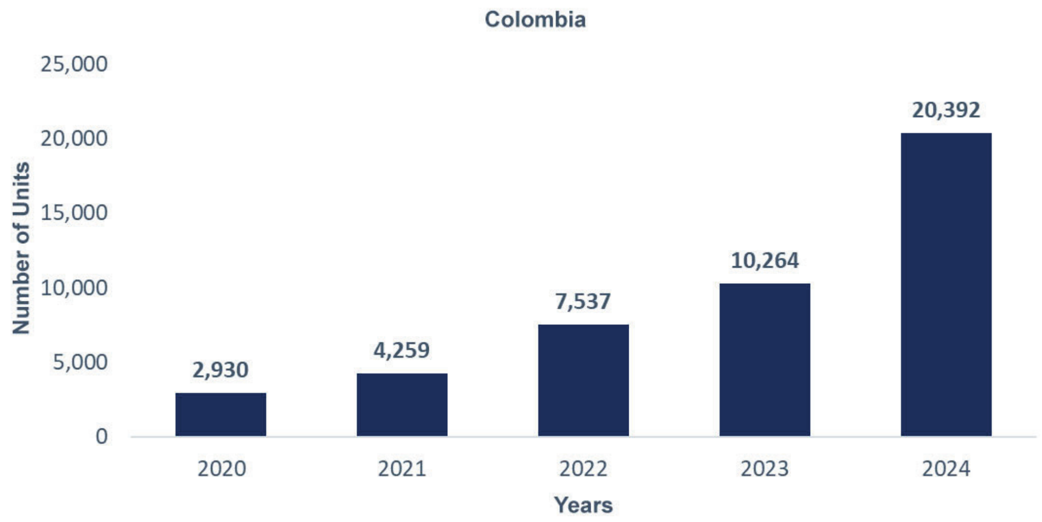
Source: Author's elaboration based on information from national statistics

Colombia

In Colombia—as in most LAC countries—the electrified light vehicle fleet has grown exponentially over the past 4 years, with an increase of nearly 100% in the last year. Nevertheless, one of the barriers that still hinders the further growth of this vehicle fleet is the insufficient availability of charging stations and points, and electricity grids to supply them with energy.

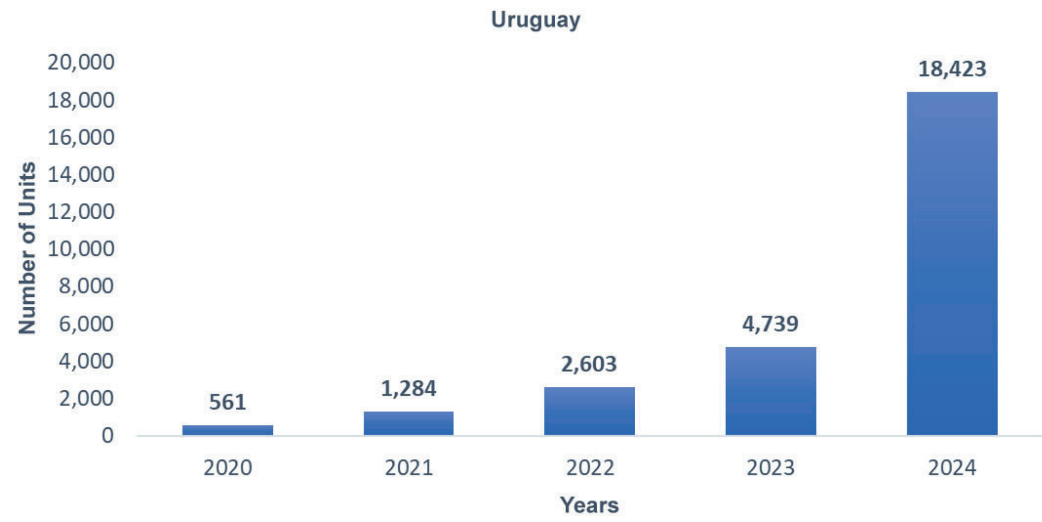
Colombia also holds significant potential to become a producer of components for the manufacture of electric vehicles and batteries, thanks to the availability of mineral resources such as nickel and copper.

Figure 7. Evolution of the electrified light vehicle fleet in Colombia 2020-2024



Source: Author's elaboration based on information from national statistics.

Figure 8. Evolution of the electrified light vehicle fleet in Uruguay 2020-2024



Source: Author's elaboration based on information from national statistics.

Uruguay

Like Costa Rica, Uruguay stands out for being a small country in territorial size and population, yet it has achieved a remarkably high number of electrified light vehicles in circulation, ranking fifth in the region.

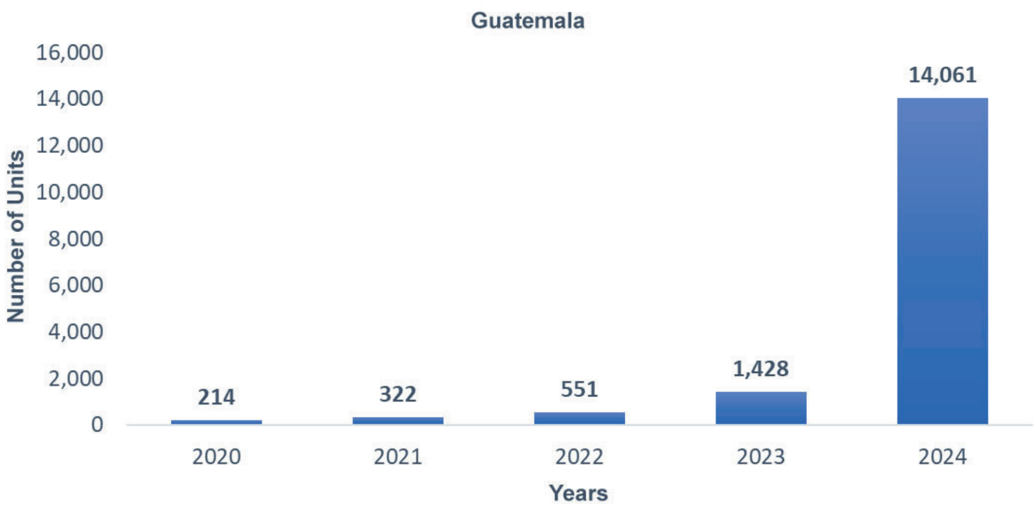
As in other countries in the region, in 2024, the fleet quadrupled compared to 2023, and grow prospects remain strong for 2025. During the first quarter of 2025, the number of 100% electric vehicles (BEVs) sold is the triple of the sales during the same period in 2024.

Although Uruguay's market can be relatively limited in absolute terms, especially compared to other countries in the region with larger populations, it has demonstrated high receptivity to technological innovation in efficient and sustainable modes of transportation.

Guatemala

Guatemala is another of the countries where 2024 was a year of resounding increase in light electric vehicles sales, and therefore in the number of units of this type of vehicle in circulation, multiplying by around 10 the number of units circulating in 2023, mainly due to tax incentives and the expansion of charging infrastructure (Figure 9).

Figure 9. Evolution of the electrified light vehicle fleet in Guatemala 2020-2024

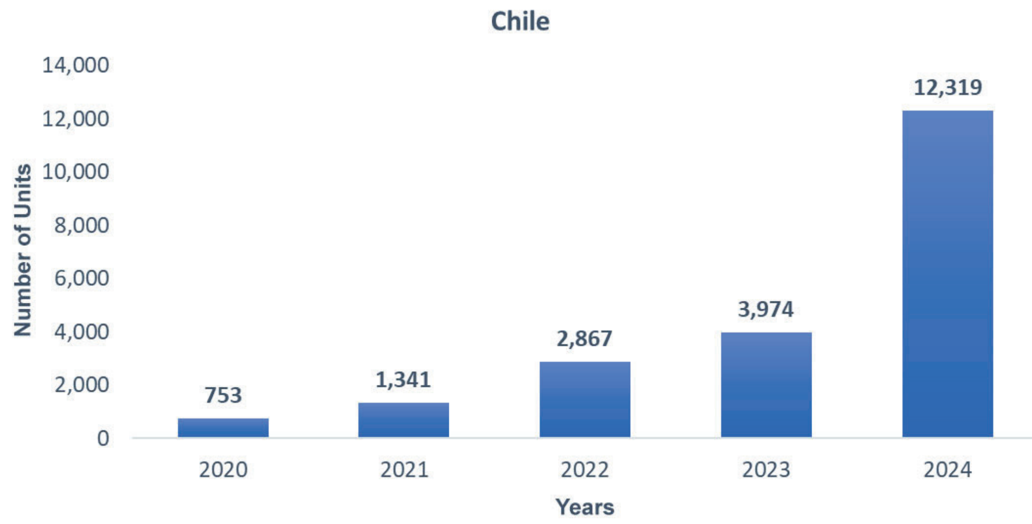


Source: Author's elaboration based on information from national statistics

Chile

In 2024, the number of light electric cars in Chile tripled compared to 2023, reflecting the country's position as one of the most proactive in providing incentives for electromobility in the region. While the growth of light vehicles fleet is notable, Chile stands out even more for the electrification of public transport, ranking first in the region in terms of electric buses in circulation.

Figure 10. Evolution of the electrified light vehicle fleet in Chile 2020-2024

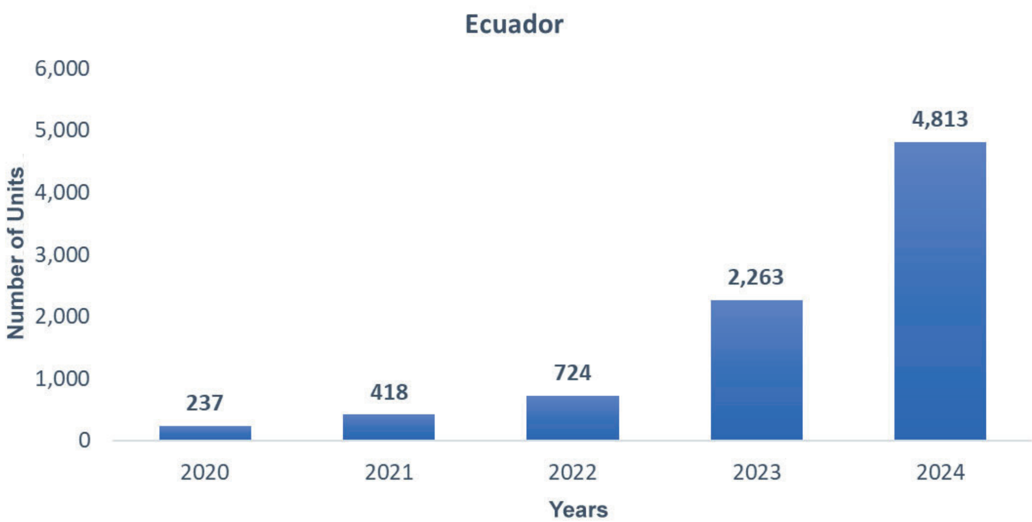


Source: Author's elaboration based on information from national statistics

Ecuador

Between 2023 and 2024, the number of units of light electric cars in circulation in Ecuador doubled. While the country has implemented some incentives to promote electromobility, the limited charging infrastructure remains as the main barrier for a widespread adoption (Figure 11).

Figure 11. Evolution of the electrified light vehicle fleet in Ecuador 2020-2024

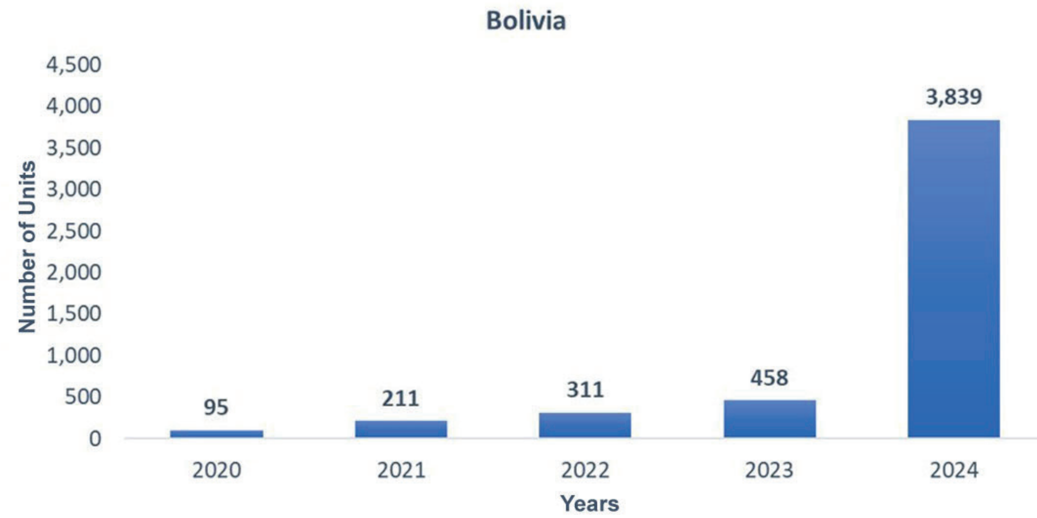


Source: Author's elaboration based on information from national statistics.

Bolivia

Between 2023 and 2024, Bolivia experienced an increase in the size of its EV fleet, being one of the LAC countries with the highest growth between these years, driven largely by government policies and incentives. Bolivia also has its own domestically manufactured electric vehicle brand, the Quantum.

Figure 12. Evolution of the electrified light vehicle fleet in Bolivia 2020-2024

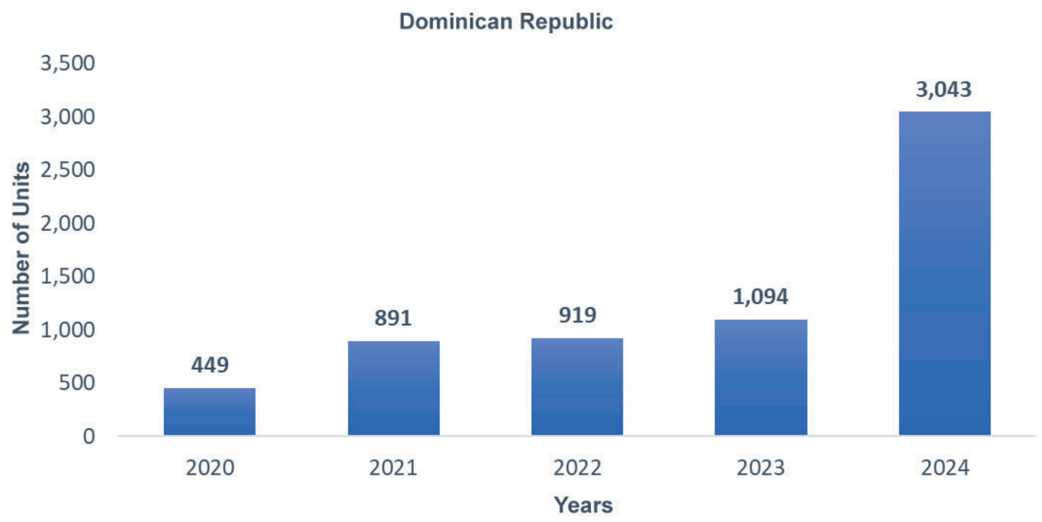


Source: Author's elaboration based on information from national statistics

Dominican Republic

As shown in Figure 13, the size of the electrified light vehicle fleet in the Dominican Republic nearly tripled between 2023 and 2024. In addition to being among the 10 countries with the largest size of its electrified light vehicle fleet in LAC, the country stands out for offering some of the most generous tax incentives in the region to promote electromobility.

Figure 13. Evolution of the electrified light vehicle fleet in the Dominican Republic 2020-2024

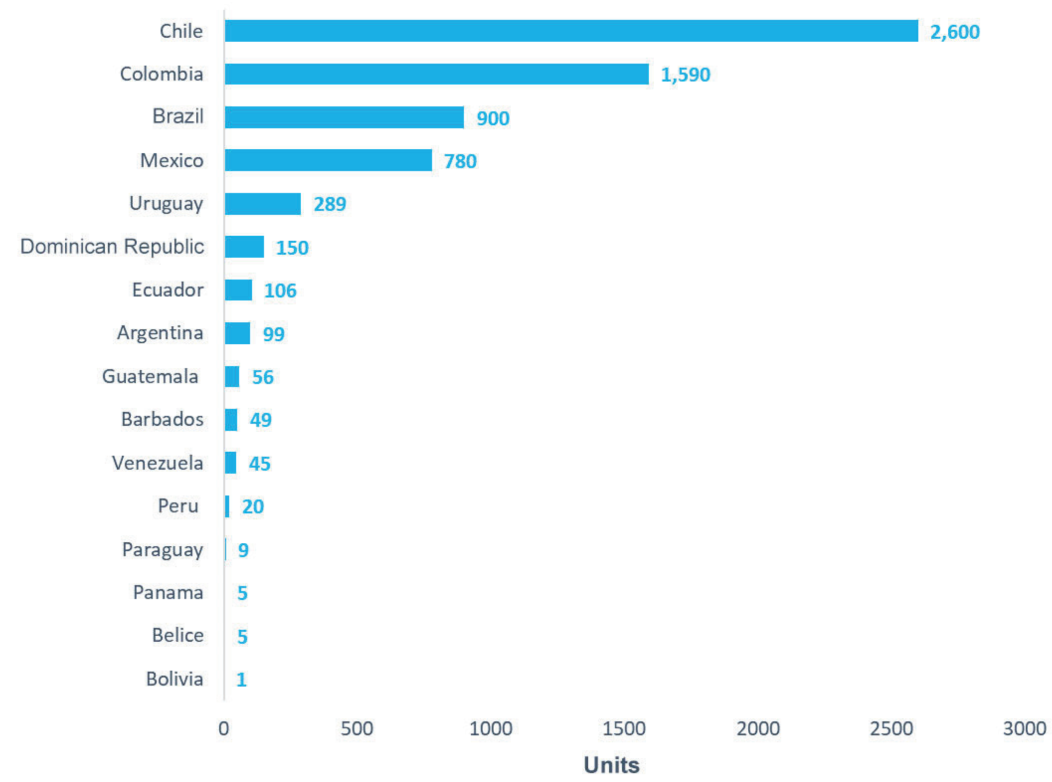


Source: Author's elaboration based on information from national statistics

Ranking of LAC countries with the highest number of electric buses (December 2024)

The development of electromobility in LAC also extends to public transport systems. The ranking of the countries with the highest number of electric buses is led by Chile and Colombia, followed by Brazil, Mexico and Uruguay in the next three positions. As of December 2024, the region's electric bus fleet reached 6,704 units, representing a 32% increase compared to the end of 2023 (Figure 14).

Figure 14. Ranking of the countries with the highest number of electric buses as of December 2024



Source: Author's elaboration based on information from national statistics

Evolution of Electrified Bus Fleet in the Five Countries with the Highest Presencee

Chile

It is worth of remark that Chile not only leads the LAC region in number of electric buses in circulation, but also ranks second worldwide, after China. In addition, according to announcements from the Chilean government, by the end of 2025, two-thirds of Santiago's bus fleet—equivalent to 4,400 units—are expected to be electric.

Colombia

Colombia is also firmly committed to positioning itself as a regional and global reference in electric public transport, beginning in 2025, the country will initiate the assembly of electric bi-articulated buses from the Chinese brand BYD.

Brazil

Although Brazil ranked third in the region in 2024 in number of electric buses in circulation—behind Chile and Colombia—, it has the potential to become the main regional market for this type of vehicle in the short term. This is largely due to the production capacity of its national industry and the support provided by the ZEBRA Partnership (an acronym for Zero Emission Bus Rapid-deployment Accelerator) led by the International Council on Clean Transportation (ICCT) and C40 Cities.

Mexico

Mexico City has the largest fleet of articulated electric buses in Latin America, and one of the largest globally. With the support of the ZEBRA Alliance, Mexico City's BRT system (Metrobus) plans to fully electrify its entire fleet of buses by 2035.

Uruguay

In 2024, Uruguay positioned itself among the Top 5 of the countries with the highest number of electric buses in circulation, aiming to achieve a 50% share of this segment in the country's total bus fleet by 2030, and a 100% by 2040.

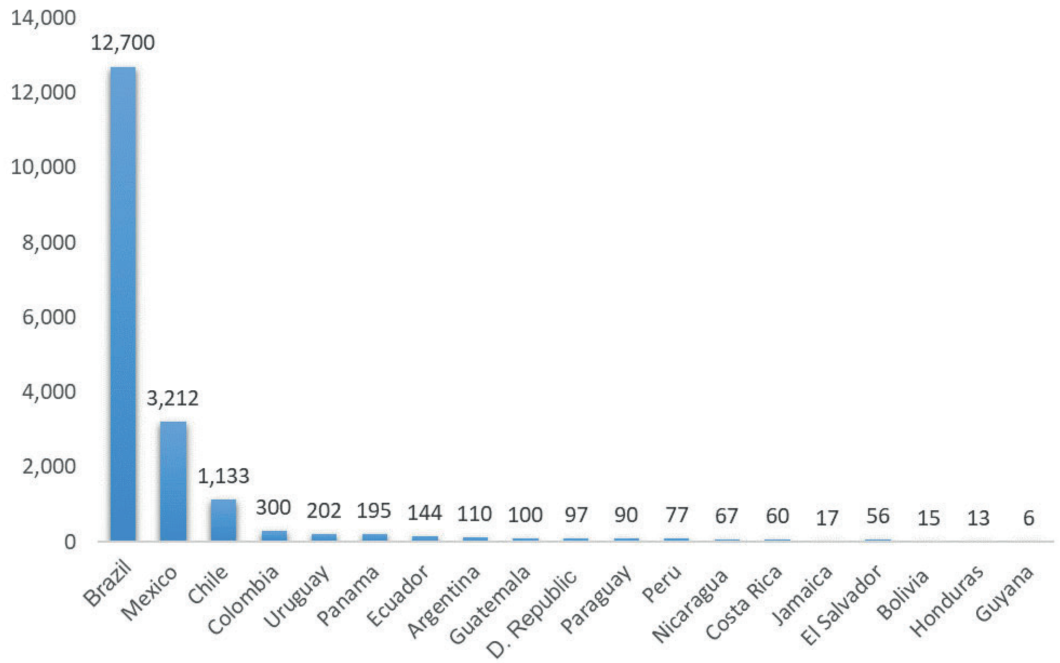
Public charging stations in LAC as of December 2024

The rapid growth in the electric vehicle fleet, has created the need to increase the number of public charging stations. As of December 2024, the region reached 18,594 charging stations, 92% concentrated in Brazil, Mexico and Chile, while the remaining 24 countries account for only 8% of the regional total. This is one of the main gaps or barriers faced by LAC countries in order to massify the sale and use of electric vehicles, particularly BEVs.

The deficit of charging stations emerges from the vicious circle between supply and demand of this service, which its implementation generally is delegated to the private sector. Given the still limited and low demand from electromobility users, the installation of public charging stations is not yet considered cost-effective for investors; and at the same time, the lack of sufficient charging infrastructure discourages the adoption of electric vehicles, particularly for long-distance travel.

Other factors that in some way also slow down the expansion of public charging stations include bureaucratic procedures for obtaining installation permits, tariff regulations, and requirements related to interoperability and digitalization. These issues are analyzed in greater detail in Chapter IV of this publication.

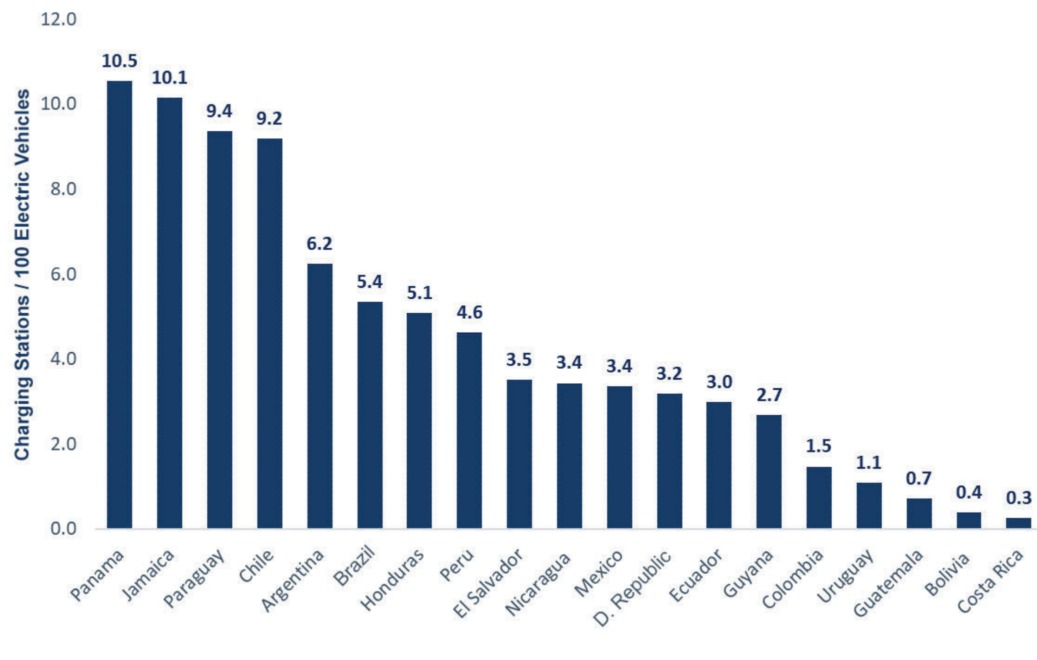
Figure 15. Ranking of the countries with the highest number of public charging stations as of December 2024



Source: Author's elaboration based on information from national statistics.

Regarding the relative number of charging stations in relation to the number of electric vehicles in circulation, the 5 countries that stand out the most are Panama, Jamaica, Paraguay, Chile, Argentina and Brazil, while some countries with an important electric vehicle fleet, such as Colombia, Uruguay and Costa Rica, are in last places, mainly due to having a relatively small number of charging stations compared to the size of their electrified vehicle fleet and the physical dimensions of their territories.

Figure 16. Countries with the highest number of public charging stations per 100 electric vehicles as of December 2024



Source: Author's elaboration based on information from national statistics

Regulation for sustainable mobility

CIn order to promote the development and advancement of electromobility in LAC countries, governments have been implementing a variety of regulatory instruments and incentives for the use of this transport technology. These measures include tax exemptions, preferential energy tariffs for electric vehicles, exemption from mobility restrictions, and parking facilities in public spaces.

Electromobility has also been included in the enactment of sectoral legislation, including laws promoting energy efficiency and environmental protection; and international agreements on interoperability and standardization of electric car battery charging systems are being promoted, supporting the creation of regional clean mobility corridors.

In relation to instruments for the promotion of electromobility, we will focus on the following:

- 1) Purchase value subsidy, corresponds to an economic incentive provided by the State or private entities to reduce the cost of acquiring electric vehicles.
- 2) Import tax reduction/exemption, refers to the elimination or reduction of tariffs or taxes applicable to the import of electric vehicles, their components (such as batteries), or charging stations.
- 3) Toll/parking exception, consists of allowing electric vehicles to access tolls, public parking lots or regulated parking areas free of charge or at a reduced rate.
- 4) Exemption of vehicle restriction, allows electric vehicles to be exempt from traffic restriction measures, such as "pico y placa" (Peak and Plate, Spanish for peak [hour] and plate [license]) or "no circula" (no drive days).
- 5) Preferential electricity rates, a reduced cost per kWh applied to the electricity consumption for charging of electric vehicles.
- 6) Charging centers regulation, refers to the set of technical, safety, and administrative standards governing the installation, operation, and maintenance of electric charging stations.
- 7) Electric Mobility National Strategy is a comprehensive public plan or policy designed by a government to promote the development and adoption of electric mobility.
- The following table summarize the instruments and incentives implemented in the different LAC countries. The green check means that the country has it, while the red x means that it does not have it, and the yellow bar means that the item is slightly developed.

Table 01. Instruments to promote electromobility

COUNTRY/INCENTIVE	SUBSIDY TO THE PURCHASE VALUE	EXEMPTION/REDUCTION OF IMPORT TAX	EXCEPTION OF TOLLS/PARKINGS	EXEMPTION OF VECHICLE RESTRICTIONS	PREFERENTIAL ELECTRICITY TARIFF	CHARGING CENTERS REGULATION	ELECTRIC MOVILITY NATIONAL STRATEGY
Argentina	✗	✗	✗	✗	✗	✗	✗
Bolivia	✓	✓	✗	✗	✓	✓	✗
Brazil	✓	✓	▬	✓	✓	✓	✓
Chile	✗	✗	✗	✓	✓	✓	✓
Colombia	✓	✓	✓	✓	▬	✓	✓
Costa Rica	✓	✓	✓	✓	✓	✓	✓
Ecuador	✓	✓	✓	▬	✓	✗	✓
El Salvador	✓	✓			✗	✗	✗
Guatemala	✓	✓			✗	✓	
Jamaica	✗	✓	✗	✗	✓	▬	✓
Mexico	✓	✓	▬	✓	✓	✓	▬
Panama	✗	✓	✗	✗	✗	✓	▬
Paraguay	✓	✓	▬	✓	✗	✓	✓
Peru	▬	✗	▬	✗	✗	✗	✗
Uruguay	✓	✓	✗	✗	✓	✓	✓

Source: OLADE, Author's elaboration based on information from national statistics

Table 01 details each of the incentives that have allowed the promotion of electric vehicles in the countries included in this analysis. In addition, this type of information provides an insight into the progress made by each of the States in the inclusion of electric vehicles into their automotive plant, in order to promote the use and purchase of electric cars.

In summary, the situation of the countries analyzed regarding incentives for electromobility is as follows:

- **Argentina** has not yet made progress in promoting electromobility in the country.

- **Bolivia** still has not made regulatory progress regarding toll exemption, vehicle restrictions, or the establishment of a national electric mobility strategy. At present, electric vehicles pay standard tolls and are subject to the same circulation rules as internal combustion vehicles.

In contrast, the country has made notable progress in other areas. Law No. 1151 on Electric Mobility/2019 (Asamblea Legislativa Plurinacional, 2019) contemplates subsidies applicable to the purchase value of electric vehicles. Likewise, Supreme Decree No. 4539 (Arce, 2019) establishes tax and financial incentives for the import, assembly and acquisition of electric and hybrid vehicles. Regarding the preferential electricity tariff, it is regulated by AETN Resolution No. 480/2021 (Sedano, 2021), setting maximum marketing rates per kWh at public charging stations according to charger type and different time blocks.

Regarding the regulation of charging stations, AETN Resolution No. 479/2021 (Sedano Julia, 2021) establishes the Technical and Safety Regulations for Electric Vehicle Charging Facilities, while AETN Resolution No. 473/2021 (Montaño, 2022) defines the procedures and requirements for the authorization of electric charging installations.

- **Brazil** has one of the most comprehensive regulatory structures for electric mobility in the region, positioning itself as a pioneer in this field. Nevertheless, the implementation of certain benefits such as exemption or toll discounts for electric vehicles, is still pending.

Regarding purchase value subsidy, Brazil currently does not offer direct incentives to final consumers. Nevertheless, the federal Mobilidade Verde e Inovação (MOVER) program has been implemented, which promotes technological innovation and energy efficiency through tax incentives for manufacturers and investors that meet low-emission and recyclability standards. This program was recently strengthened by Law No. 15,071/2024 (Barbosa Luciana, 2024), which consolidates its tax and operational framework to promote electromobility.

In relation to the exemption or reduction of import taxes, Brazil applies the CAMEX/GECEX measure (GECEX-CAMEX, 2025) issued in 2023, which regulates the gradual reintroduction of the Import Tax (II) on electric vehicles, after having been exempt from 2015 until the end of 2023.

Regarding the exemption from vehicle restrictions, Municipal Law No. 15,997/2014 stands out (Haddad Fernando, 2014), currently in force in São Paulo. This regulation grants an exemption from the city's rodizio scheme to 100% electric, hybrid electric and hydrogen-powered vehicles.

Regarding the tariff regime, the Agência Nacional de Energia Elétrica (ANEEL) issued the Normative Resolution No. 819/2018 (ANEEL, 2018), which enabled the commercialization of charging services for electric vehicles for the first time. Subsequently, Normative Resolution No. 1,000/2021 (ANEEL, 2021) consolidated the regulatory framework for energy distribution, formally recognizing recharging as a permitted service with costs at market prices, without being subject to state tariff regulation.

In relation to charging centers regulation, Brazil requires that charging stations must be certified by the National Institute of Metrology, Quality and Technology (Instituto Nacional de Metrologia, Qualidade e Tecnologia/INMETRO), in compliance with the technical standard ABNT NBR IEC 61851-1:2021, which ensures interoperability and safety conditions. In addition, Law No. 14,902/2024 (Rebelo Luis, 2024) strengthens the MOVER Program, establishing mandatory targets for energy efficiency, recyclability and reduction of CO_2 emissions for vehicles, applicable from June 2025 and projected until 2030–2031. This legislation also contemplates specific technical requirements for the marketing and import of electric and hybrid vehicles.

- **Chile**, despite being a regional benchmark in energy, still does not contemplate a direct subsidy on the purchase value of electric vehicles (EVs). Likewise, there is no differentiated tax regime for the import of this type of vehicle, nor reduced toll rates for their circulation. Nevertheless, the country has implemented significant measures in other key areas. Exempt Resolution No. 1555/2020 (Roldán Eddy, 2020) of the Ministry of Transport and Telecommunications (Ministerio de Transporte y Telecomunicaciones), grants exemptions from the vehicle restriction system in the Metropolitan Region of Santiago for electric and plug-in hybrid vehicles.

As for the preferential electricity tariff, Chile operates under a regulated tariff system set by the Ministry of Energy, which are established for a period of four years. While there is no exclusive tariff for electric vehicle charging, it is expected to be included in differentiated distribution schemes in the future.

Regarding charging infrastructure, Chile advanced through the adoption of specific technical regulations. Technical Specification No. 15/2020 (Superintendencia de Electricidad y Combustibles, 2024) establishes the minimum requirements for safety, design, electromagnetic compatibility, and electrical protection for public and private chargers. In addition, Exempt Resolution No. 33,675 (Ávila, 2020) requires that all power supply systems and cables used in EV charging must have prior approval by the Superintendence of Electricity and Fuels (Superintendencia de Electricidad y Combustibles/SEC).

Finally, under the framework of the National Electromobility Strategy, Chile has set ambitious goals: beginning in 2035 (Ministerio de energía, 2021b), all new light vehicles sold in the country must be 100% electric. In addition, it is projected that at least 40% of the private vehicle fleet will be electrified by 2050.

- **Colombia** is positioned as one of the pioneering countries in the region in the promotion of electromobility, thanks to a comprehensive regulatory framework that promotes the adoption of electric vehicles (EVs). Among the key instruments, virtually al have been developed by the State, with the only pending measure being the establishment of a preferential electricity tariff for EV users.

Regarding the purchase value subsidy, Law 1964 of 2019 (Electric Mobility Law) (Suárez, 2019) establishes a set of incentives to encourage the acquisition of EVs, including tax exemptions, deductions and additional benefits for users. For its part, the exemption or reduction of the import tax is regulated under Decree 1116 (Ministerio de Comercio, Industria y Turismo, 2017), which sets a 0% tariff for electric vehicles and reduced tariffs for hybrids, subject to limited annual quotas.

Regarding toll exemption and parking benefits, Law 1964 of 2019 specifies in Article 7 that municipalities of special category, first or second (according to Law 617 of 2000) must allocate at least 2% of their public and private parking spaces for electric vehicles. In addition, cities such as Bogotá and Medellín have exempted electric and hybrid vehicles from the vehicle restriction scheme (pico y placa), in line with the provisions of the law.

In the charging infrastructure area, Resolution 40223 of 2021 (Régimen Legal de Bogotá D.C), issued by the Ministry of Mines and Energy (Ministerio de Minas y Energía), establishes minimum technical requirements for electric charging installations. The resolution addresses key aspects such as standardization, service quality, safety, and user rights.

Law 1964 of 2019 also creates the Fondo Nacional de Movilidad Eléctrica (Electric Mobility National Fund), which sets targets for the electrification of at least 1% of public transport fleets, and provides a range of fiscal and financial support mechanisms. This framework was complemented by Decree 1898 of 2023 (Bonilla, 2023), which reinforces the National Electric Mobility Strategy by linking tariff benefits to compliance with technical standards, safety criteria and national production of sustainable mobility technologies.

- **Costa Rica** stands out as one of the leading countries in Central America in terms of electromobility, supported by a comprehensive regulatory framework that encompasses all instruments necessary to promote the adoption of electric vehicles (EVs).

Regarding the purchase value subsidy, Law No. 9518 (2018), "Ley de Incentivos y Promoción para el Transporte Eléctrico" (Sistema Costarricense de Información Jurídica, 2018a), establishes temporary exemptions from Value Added Tax (VAT), Selective Consumption Tax, and Customs Value Tax. For import tax exemptions, the same Law 9518 applies a tiered structure based on vehicle price. Full exemptions are granted for vehicles valued up to $30,000; while vehicles priced between $30,001 and $60,000 receive reduced discount tariffs.
Regarding toll and parking benefits, Law 9518 authorizes local gov-

ernments to establish exemptions for the use of parking meters and mandates that at least 2% of parking spaces in public areas and commercial establishments be reserved for electric vehicles.

The exemption from vehicle restriction is also established under Law 9518 and its technical regulations, promoted by the Ministry of Environment and Energy (Ministerio de Ambiente y Energía, MINAE) since 2012. According to this regulation, electric vehicles are exempt from vehicle restriction by license plate number in the San Jose Metropolitan Area.

As for the preferential electricity tariff, it is regulated by Resolution RE-0056-IE-2019 (RE-0129-IE-2020, 2020) of the Public Service Regulating Authority (ARESEP), in compliance with Executive Decree No. 41642-MINAE (2019) (Sistema Costarricense de Información Jurídica, 2018b) and Law 9518. This resolution establishes a transitional rate of ₡182.72 per kWh for the national fast-charging network.

The regulation of charging centers is established under Executive Decree No. 41642-MINAE, which sets the technical regulations for the construction and operation of the charging network by electricity distribution companies. The National Electric Mobility Strategy, framed in Law 9518, defines the institutional structure of electric transport in Costa Rica, including tax benefits, free transit, deployment of infrastructure (such as electric buses and taxis), policies for public and private fleets, and technical training. This strategy is complemented by the National Decarbonization Plan 2018–2050 (Ministerio del ambiente y Energía, MINAE, 2019), which sets concrete targets such as the renewal of public and private fleets toward zero-emission technologies, and the construction of fast-charging infrastructure at intervals of 80 km on national roads and 120 km on cantonal.

- **Ecuador** is progressively advancing toward the consolidation of its electric mobility ecosystem, with a comprehensive regulation for charging centers currently being implemented. The country is also in the process of incorporating regulations to allow the free circulation of electric vehicles nationwide. Nevertheless, the rest of the key incentives have already been developed and are in place.

The purchase value subsidy is covered under the Organic Law for Productive Development, Investment Attraction, Employment Generation and Fiscal Stability, complemented by COMEX Resolution No. 016-2019 (COMEX, 2019). This resolution establishes a 0% import tariff, along with exemptions from Value Added Tax (VAT) and Selective Consumption Tax (ISC) for electric vehicles, batteries and chargers, provided the FOB value does not exceed USD 40,000. Regarding import tax exemption or reduction, COMEX Resolution No. 016-2019 serve as the primary instrument, fully eliminating tariffs for the import of electric vehicles and their essential components.

In terms of vehicle circulation, the National Policy for Sustainable Urban Mobility establishes in articles 214C and 214D, that 100% electric vehicles are exempt from restrictions such as "pico y placa", and are granted free access to public parking lots under the administration of the Decentralized Autonomous Governments (Gobierno Autónomo Descentralizado/GAD).

Regarding the preferential electricity tariff, Ecuador was a pioneer with ARCONEL Resolution No. 038/2015 (ARCONEL, 2015), which established a preferential overnight rate of USD 0.05/kWh for charging electric vehicles via independent metering. Subsequently, in 2023, more detailed provisions were introduced for public stations through ARCONEL Resolution No. 036/2023 and the SCVE 2024 Tariff Specifications, which were updated by ARCONEL Resolution No. 024/2024 (ARCONEL, 2024), establishing maximum rates differentiated by type of charger and time of day.

The National Electric Mobility Strategy (IDB, 2021) projects to reach at least 100,000 electric vehicles in circulation by 2030 and over 750,000 by 2040. This strategy encompasses tax incentives, deployment of charging infrastructure, technical regulations, incorporation of public and private fleets, and transition plans, all aligned with the National Policy for Sustainable Urban Mobility 2023–2030.

- **El Salvador** still does not have a specific regulation for charging stations nor a preferential electricity rate for electric vehicle charging. Likewise, the country has not adopted a formal national strategy that comprehensively promotes electric mobility. Nevertheless, initial steps have been taken through Legislative Decree No. 738/2020, "Ley de Fomentos e incentivos para la importación y Uso de Vehículos Eléctricos e Híbridos" (Law of Promotion and Incentives for the Import and Use of Electric Vehicles) (Asamblea Legislativa, 2021), which establishes a range of fiscal and tax benefits aimed at encouraging the adoption of cleaner transport technologies.

Among the incentives related to the purchase value subsidy, the law provides:

- Exemption from Value Added Tax (VAT) on the import of new electric vehicles.
- Exemption from the First Registration Tax (ISPM) for new electric and hybrid vehicles.
- Exemption from the payment of the annual vehicle fee for the first two years (100% of the cost).
- Exemption from Income Tax (ISR) on earnings generated by companies that provide electric charging services for a period of five years.

Regarding the exemption or reduction of import taxes, the decree provides:

- Full exemption from import tariff for new electric and hybrid vehicles.
- Exemption from VAT and ISPM (First Registration Tax) applicable to this type of vehicle.
- Inclusion of electric bicycles and velocipedes within the VAT exemption regime.
- Equipment, components and spare parts used in charging stations also benefit from tariff and tax exemptions.

In addition, in August 2022 (Asamblea Legislativa, 2022), a reform to the regulatory framework extended these benefits to used electric and hybrid vehicles, providing a partial exemption of 25% on VAT for these units.

- **Guatemala** has established a solid regulatory basis to promote electric mobility, although it does not yet provide a specific preferential electricity tariff for electric vehicle charging. The rest of the incentives have been incorporated through current legislation, particularly the Incentives for Electric Mobility Law (Decree No. 40-2022) (Congreso de la república, 2022) and Governmental Agreement 295-2022, which is a regulation of the Law on Incentives for Electric Mobility. This instrument complements the Law on Tax Incentives for Electric Mobility (Decree 40-2022), which mainly defines how tax incentives will be applied for the purchase and use of electric vehicles and promoting the use of electric vehicles by reducing emissions.

Regarding the purchase value subsidy, Guatemala's regulations provide the following benefits:

- 100% exemption from Value Added Tax (VAT) on the import and first sale of electric, hybrid, hydrogen and electric transport vehicles, whether new or locally assembled.
- Full exemption from the Specific Tax on First Registration (IPRIMA) for a period of 10 years from the law's entry into force.
- Exemption from annual road tax for electric vehicles used in public and private sectors, applicable for 10 years with a progressive reduction over time.
- Exemption from Income Tax (ISR) for a period of 10 years on income generated by assembly activities, EV production, or the provision of electric public transport services.

In relation to the exemption or reduction of import taxes, Decree 40-2022 establishes a 0% tariff for the duration of the law (10 years) on the import of electric, hybrid and hydrogen vehicles, as well as their components, chargers and electric bicycles.

In relation to the regulation of charging stations, Resolution CNEE-69/2023 (Solórzano, 2023), issued by the National Electric Energy Commission (Comisión Nacional de Energía Electrica/CNEE), establishes minimum technical requirements for the design, construction, operation, and maintenance of charging stations. The regulations prohibit the resale of energy at unauthorized charging points and set specific penalties for non-compliance.

- **Honduras** has developed the National Electric Mobility Strategy (Estrategia Nacional de Movilidad Eléctrica/ENME) as an initiative of the Secretariat of Energy (Secretaría de Energía/SEN)

to promote electromobility, reduce dependence on fossil fuels and reduce greenhouse gas emissions. Prepared with the support of co-operating partners (GIZ, MOVE/UNEP), the strategy outlines a road-map for the implementation of electromobility, aiming to improve citizens quality of life and meet global climate commitments. The ENME is aligned with the Government Bicentennial Plan 2022-2026, promoting high-efficiency and low-consumption vehicles, and is integrated with the Climate Justice Agenda, which seeks solutions to increase resilience and adaptation to climate change. The trans-port sector, being one of the largest consumers of hydrocarbons, accounts for a significant percentage of the country's total emis-sions within the energy sector. The current state of electric mobil-ity in Honduras—still without incentives—is marked by an incipi-ent increase in electric vehicles (EVs) and light hybrids, including electric trucks for product logistics, motorcycles, and heavy-duty vehicles, among others, with several EV dealers already installing semi-fast chargers, commercial bank financing options, and insur-ance products. Honduras has made progress with the adoption of technical standards covering electrical installation requirements for EVs, conductive charging and interoperability systems, batter-ies, charging centers requirements, and others. The ENME aims to address the main barriers to electric mobility adoption, including the absence of a legal and regulatory framework, the lack of eco-nomic and social incentives, and limitations in infrastructure and technology.
The implementation of the ENME requires the coordinated partici-pation of multiple actors, including government, private sector, ac-ademia, and civil society. The strategy establishes specific targets for 2030 and 2050, aiming for electric vehicles to comprise a sig-nificant percentage of the national vehicle fleet, thereby contribut-ing to a more sustainable and cleaner future for Honduras (Source: https://sen.hn/electromovilidad/)

• **Jamaica** is currently developing a regulatory framework to govern the use and interoperability of electric charging stations. Nevertheless, the country still does not have direct subsidies for the acquisition of electric vehicles by individuals. In addition, there are no provisions exempting these vehicles from driving restric-tions, nor has differential treatment established for toll collection compared to combustion vehicles

Regarding the exemption or reduction of import taxes, specific measures have been adopted through the Customs Tariff (Amend-ment) (No. 2)(ALPHEA SUMNER, 2022), Resolution 2022 (CMC, 2022), and the Road Traffic (Licence Duties) Order (Bennettk, 2024). These regulations reduced the import tariff on new electric vehicles (≤3 years old) from 30% to 10%, and exempt them from paying the license fees for a period of five years.

Regarding the preferential electricity tariff, since 2021, Jamaica Public Service (JPS) (Bennettk, 2021), the country's main electricity distributor, received authorization from the Office of Utilities Regu-lation (OUR) to apply differentiated time-of-use rate schemes. This measure aims to encourage charging at periods of low demand.

As for the national electric mobility strategy, it is currently under development in coordination with the Ministry of Science, Ener-gy and Technology (MSETT), and the Inter-American Development Bank (IDB). The roadmap includes:

- The design of a national electromobility policy.
- The application of reduced tax standards.
- The definition of a specific tariff structure for EV charging.
- The establishment of technical regulations for charging sta-tions.
- The evaluation of fleets alongside with technical training programs for human capital.

• **Mexico** is currently in the process of developing a national electric mobility strategy aimed at consolidating the diverse regu-latory, fiscal and technical efforts on electromobility. Among the pending challenges remain the incorporation of specific incentives that allow the exemption of toll payment for electric vehicles.

As for the purchase value subsidy, this is implemented through Tax on New Cars (Impuesto Sobre Automóviles Nuevos/ISAN). Ac-cording to Article 16 of the Federal Revenue Law 2015 (Cámara de Diputados, 2023), vehicles whose propulsion is powered by re-chargeable electric batteries, electric hybrids or that use hydrogen are exempt from ISAN.

Regarding the reduction of import taxes, the " Decreto por el que se modifica la Tarifa de la Ley de los Impuestos Generales de Importación y de Exportación " (Decree amending the Tariff of the Law on General Import and Export Taxes) establishes specific tariff codes for new electric vehicles, with a tariff of 0% for a certain period, favoring the import of this type of vehicle.

In terms of exemption from driving restrictions, several states—such as Mexico City and Jalisco—have established local regulations that exempt electric and plug-in hybrid vehicles from the vehicle verification program and traffic restrictions (such as the "Hoy No Circula").

In relation to the preferential tariff, the Federal Electricity Commission (CFE) (Zarco, 2024) authorizes the installation of an exclusive meter for electric vehicles charging at no additional cost. This measure facilitates differentiated tariffs based on the user's specific consumption. The regulation of charging stations has been formalized by the Energy Regulatory Commission (CRE) through Agreement A/108/2024 (Comisión Reguladora de Energía, 2024), which establishes the General Administrative Provisions on electromobility. This document regulates the integration of charging infrastructure for electric and plug-in hybrid vehicles into the National Electric System, addressing technical, connection, and operational safety aspects.

- **Panama** has so far implemented the incentive related to the reduction of taxes on the import of electric vehicles, while progressing in the development of a national electric mobility strategy. In this context, Law No. 295 of 2022 (Asamblea Nacional, 2022) establishes a set of incentives to promote electric mobility in land transport. According to this regulation, new electric vehicles are exempt from the Selective Consumption Tax (ISC) until December 31, 2030; From that date, a reduced rate of 5% will apply. Likewise, the import of these vehicles is only subject to the payment of 7% of the ITBMS (equivalent to VAT), without additional ISC surcharges.

On the other hand, the regulation of electric charging stations was established through Executive Decree No. 51 of 2023 (Ministerio de la Presidencia, 2023) which regulates Law 295 and defines the technical, operational, and procedural guidelines of mandatory compliance for the installation and operation of electric charging infrastructure throughout the national territory.

- **Paraguay** has made substantial progress in promoting electromobility, with concrete efforts aimed at establishing a preferential toll rate for electric vehicles—currently in the implementation stage—although there is still no national legislation that fully regulates charging stations.

As for the purchase value subsidy, it is contemplated in Law No. 6925/2022 (Osorio, 2022), known as the "Ley de incentivos y Promoción del Transporte Eléctrico en el Paraguay" (Law of Incentives and Promotion of Electric Transportation in Paraguay). This legislation grants exemption from the Customs Import Tax and the Value Added Tax (VAT) for the import of new electric vehicles, as well as for the import of spare parts related to the electric traction system and vehicle batteries. The same Law 695/2022 also covers the reduction or exemption of import taxes, including tax benefits for essential parts and components of the electric mobility ecosystem.
In relation to vehicle restriction and licenses, Article 13 of Law 695/2022 establishes an exemption from the vehicle license tax for electric vehicles for a period of five years, with a progressive annual reduction.

Regarding the regulation of charging stations, the Municipality of Asunción issued Ordinance No. 204/2019 (Comisiones de Legislación y de Hacienda y Presupuesto, 2019), which regulates the installation of electric charging centers in public spaces. This local regulation establishes minimum technical requirements and installation guidelines to ensure the safety and functionality of the charging infrastructure.

The National Electric Mobility Strategy (ENME) was officially enacted through Decree No. 8840/2023 (Ministerio de Industria y Comercio, 2023), which establishes a comprehensive strategic framework to foster the transition to sustainable mobility. The decree also creates the Strategic Council for Electric Mobility (CEME), which seeks to capitalize Paraguay's clean energy potential and promotes policies for the electrification of transport, infrastructure development, tax incentives and institutional coordination.

- Peru is in the process of approving incentives, including a subsidy on the purchase value of EVs, and the collection of a preferential toll rate where this type of transport circulates. Regarding other incentives, the country does not have any. As a result, Peru is slightly ahead of Argentina, solely due to the incentives currently in process of being approved.

- **Uruguay** has established itself as a regional referent in the energy sector, thanks to its predominantly renewable electricity matrix. In addition, the country has implemented a 50% reduction in the license plate (patente de rodados) for electric vehicles (Ministerio de Industria, Energía y Minería (MIEM). Uruguay, 2024).

Regarding the purchase value subsidy, Uruguay has implemented the SUBITE Program, an initiative promoted by the National Energy Directorate of the MIEM, to promote the transition toward sustainable mobility through the use of electric vehicles. This program provides direct financial support for the purchase of Buses, passenger transport vehicles, motorcycles and tricycles, logistics vehicles, and also includes an incentive program for electric vehicles leasing. Some of the calls under these programs are currently closed at the time of publication.

In relation import tax exemption, Decree No. 325/017 established a Global Tariff Rate (Tasa Global Arancelaria or TGA) of 0% for electric vehicles, classified under specific Mercosur tariff codes, thereby facilitating their entry into the local market. In 2019, this exemption was extended to cover charging systems and lithium batteries for the automotive industry (Ministerio de Industria, Energía y Mineria (MIEM), 2019). This decision was ratified in 2023.
It is also important to highlight the elimination of the IMESI (Specific Internal Tax/Impuesto Específico Interno) on electric vehicles, which in some cases could represent up to 45% of a vehicle's sale value, this measure was enacted through Decree No. 390/021, published on December 7, 2021. (Ministerio de Economia y Finanzas, Uruguay, 2021)

In the preferential electricity tariffs area, the National Administration of Power Plants and Electrical Transmissions (UTE) launched the Electric Mobility Plan (Plan de Movilidad Eléctrica, UTEC, 2023), which offers reduced rates for owners of electric vehicles (categories M1 and M2 of the Mercosur Technical Regulations) acquired since 2018. To qualify, the vehicles must be equipped with a lithium battery and used for the transport of passengers or light cargo.

In relation to the regulation of charging centers, the Regulatory Entity for Energy and Water (URSEA) approved Resolution No. 368/023 (URSEA, 2023), which established the technical requirements for Electric Vehicle Power Systems (SAVE). Among the provisions, it mandates that public access charging points must include at least one type 2 (AC) and one type CCS2 (DC) connector, while also requiring that all chargers located in the same point provide similar power levels.

The National Electric Mobility Strategy (ENME) is implemented through the MOVÉS Project (UTEC, 2023), a state initiative that promotes a sustainable, efficient, low-carbon, and inclusive transport system. This strategy contemplates the development of institutional capacities, specific regulations, the adoption of new technologies, and the promotion of a cultural change towards clean mobility.

Table 02. Standardization and operability

COUNTRY/INCENTIVE	ENERGY EFFICIENCY LAW	STANDARDS FOR THE FUNCTIONING OF ELECTRIC VEHICLES	CHARGING INFRASTRUCTURE STANDARDIZATION	STANDARDS FOR COMMUNICATION AUTO-GRID	LIGHT VEHICLES' EMISSIONS REDUCTIONS
Argentina	✓	✗	✗	✗	✓
Bolivia	—	—	✓	✗	✓
Brazil	✓	✓	✓	—	✓
Chile	✓	—	—	✗	✓
Colombia	✓	—	✓	✓	✓
Costa Rica	✓	✓	✓	✗	✓
Ecuador	✓	✓	✓	✗	✓
El Salvador	—	✓	✗	✗	✓
Guatemala	✓	✗	✓	✗	✓
Jamaica	✓	—	—	✗	✓
Mexico	✓	✗	✓	✗	✓
Panama	—	✗	✗	✗	—
Paraguay	✓	✓	✓	✗	✓
Peru	✓	✓	✓	✗	✓
Uruguay	✓	✓	✓	—	✓

Source: OLADE, Author's elaboration based on information from national statistics.

Table 02 presents a summary of the countries that have an optimal standardization for the integration of electric vehicles into their vehicle fleet. This overview also provides insight of operability of electric vehicles within their territories, by identifying the existing EV's regulations and restrictions. Within the scope of standardization and operability, the following aspects will be analyzed:

- Energy Efficiency Law: This law establishes mandatory and voluntary guidelines in order to all energy systems, including electric transportation, to operate under standardized minimum efficiency criteria.
- Standards for EV operation: Define the minimum technical requirements that an EV must meet in order to be approved and operate legally.
- Standardization of Charging Infrastructure: Refers to the set of technical standards governing the installation and operation of charging stations, ensuring that different electric vehicles can use a common network..
- Standards for Vehicle-Grid Communication: Establish the communication protocols between the vehicle and the smart grid, enabling interoperability between the car's software, the charging station and the grid operators.
- Emission Reduction of Light Vehicles: Define maximum emission levels for new and in-circulation vehicles, in accordance with international standards (such as Euro or EPA).

Summary of the situation by country:

- **Argentina** has advanced in the implementation of regulatory measures aimed at energy efficiency and emission reduction from the vehicle fleet. Nevertheless, important gaps persist in the standardization of infrastructure and specific components for electric vehicles (EVs).

  In terms of energy efficiency, Argentina has a consolidated regulatory system governing the energy consumption of light vehicles. MAyDS Resolution No. 797-E/2017 (Ministerio de Ambiente y Desarrollo, 2017), introduced mandatory energy efficiency labeling for new light vehicles, based on the IRAM-AITA 10274-2 standard. This system measures and classifies performance in consumption and CO_2 emissions, enabling consumers to make informed choices. This was reinforced by MAyDS Resolution No. 383/2021 (Ministry of Environment and Development, 2021), which requires all retail locations—physical and digital—to display these labels, which classify vehicles into categories ranging from A+ (most efficient) to E (least efficient).

  As for reducing vehicle emissions, Argentina has adopted international standards, particularly those established for light vehicles by the European EURO V standard. MAyDS Resolution No. 1464/2014 (Secretaría de Ambiente y Desarrollo, 2014) requires that all new vehicles marketed in the country comply with the emission limits sets by the UNECE R83 and R101 regulations, which measure pollutant emissions and fuel consumption. Argentina also actively participates in the National Program for the Evaluation of Vehicle Consumption and Emissions. In addition, the recent SE-MEC Resolution No. 289/2024 (Ministerio de Economía, 2024) creates the National Sustainable Mobility Program, aimed at promoting the transition toward clean technologies in public and private transport. The program encourages emission reductions through financial incentives, fleet renewal and the incorporation of more efficient and less polluting vehicles.

- Bolivia has made partial progress in the regulation of electric mobility, with particular attention on the reduction of pollutant emissions and the standardization of charging infrastructure. Nevertheless, the country is still in the process of incorporating essential regulations, such as an energy efficiency law and technical standards for the operation of electric vehicles (EVs). Additionally, Bolivia currently lacks vehicle-grid communication protocols, which are essential for intelligent integration of EVs with the electricity system.

  Regarding the standardization of charging infrastructure, Supreme Decree No. 4539/2021 (Arce, 2019) promotes the construction and operation of public and private charging stations as part of Bolivia's electromobility incentives. In addition, the Electricity and Nuclear Technology Authority (AETN) has issued key regulations that establish differentiated tariffs for electric charging and regulates the technical and safety requirements that charging facilities must comply.

  In terms of reducing emissions from light vehicles, Law No. 821/2016 (Asamblea Legislativa Plurinacional, 2016), which amends the General Transport Law, establishes in Article 191 that imported vehicles must comply with emission standards equivalent to EURO II or higher. The law also prohibits the import of vehicles that do not meet these standards, unless compatible fuels are available in the country, allowing a maximum adaptation period of five years.

- **Brazil** is positioned as one of the most advanced countries in Latin America regarding electromobility, having implemented nearly all the necessary incentives to integrate electric vehicles (EVs) into its vehicle fleet. Nevertheless, the country is still in the process of incorporating standardized communication protocols between the EV and the electricity grid, which would enable intelligent interoperability in the future.

  In terms of energy efficiency, the regulatory framework is guided by the Decree establishing the Mobilidade Verde e Inovação –MOVER (Green Mobility and Innovation Program), signed in April 2025 (Secretaría Especial para Asuntos Jurídicos, 2025). This instrument establishes mandatory technical, environmental, and minimum energy efficiency parameters for vehicle manufacturers and importers, effective since June 2025. Its guidelines include energy efficiency criteria under the "poca-a-roda" (well-to-wheel) approach, components recyclability and requirements for a greater environmental transparency in vehicle commercialization.

  Regarding the standardization of EV technical operation, the MOVER program establishes the foundation for the formulation of mandatory standards on on-board energy efficiency, electrical safety, and environmental labeling. While these standards are still under development, the decree grants the state the authority to establish mandatory federal technical standards, driving the sector's future standardization. The charging infrastructure is regulated by ANEEL Resolution No. 1.059/2023 (AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA – ANEEL, 2023), which sets the operational requirements for the provision of electric vehicle charging services. This resolution permits charging Point Operators (CPOs) to offer services without requiring a concession like traditional electricity distributors. It also requires minimum conditions for electrical safety, consumption measurement, and differentiated time-of-use rates, incentivizing charging during off-peak hours. Although it does not yet constitute a definitive law, the resolution represents the regulatory framework closest to an operational standardization in force in Brazil.

  In relation to emission reduction from light vehicles, Brazil implements the Air Pollution Control Program for Motor Vehicles (PROCONVE), administered by the National Council for the Environment (CONAMA). This program has adopted international emission standards equivalent to the European standards:
  - CONAMA Resolution No. 415/2009 (CONAMA, 2009): implements the L6 phase (equivalent to Euro 5) from 1 January 2015, mandatory for all new light vehicles.
  - CONAMA Resolution No. 492/2018 (MINISTÉRIO DO MEIO AMBIENTE, 2018): establishes the PROCONVE L7 stage (similar to Euro 6), effective from 1 January 2022. Sets strict emission limits for NMOG+NO_x (80 mg/km), PM (6 mg/km), CO (1000 mg/km), and regulations for evaporative emissions. It also mandates emissions durability of at least 160,000 km or

10 years and requires testing under real driving conditions.
- PROCONVE L8 (From 1 January 2025): Begins progressive implementation of the L8 stage, introducing even more stringent limits and incorporating innovative technologies such as vapor recovery systems (ORVR).

- **Chile** is among the Latin American countries with the most significant advances in energy efficiency applied to transport and in the regulation of the vehicle sector emissions. Nevertheless, the implementation of technical standards for the specific operation of electric vehicles (EVs), the standardization of charging infrastructure, and communication protocols between EVs and the electricity grid are still under development and not incorporated into the national regulatory framework.

  In terms of energy efficiency, the country has the Law No. 21,305 of 2021 (Ministerio de Energía, 2021a), which establishes mandatory energy efficiency standards for light, medium and heavy vehicles for the first time.
  Article 6 of this law empowers the Ministry of Energy to regulate vehicle energy efficiency, expressed in kilometers per liter of gasoline equivalent, as well as its equivalent in grams of CO_2 per kilometer. The technical regulation of this law is developed through the Supreme Decree No. 41/2022 (Ministerio del Trabajo y Previsión Social, 2021), which establishes procedures for the approval of minimum energy efficiency standards for new vehicles. It also defines the obligations of importers, manufacturers and representatives, the calculation methodology and the penalties for non-compliance, which can reach up to 0.2 UF (Unidades de Fomento) for every tenth of a kilometer per liter below the established standard.

  In the area of pollution emission reduction from light vehicles, Chile has adopted international standards equivalent to European regulations, through a series of progressive decrees. Supreme Decree No. 211/1991(Ministerio de Obras Públicas, 1989) introduced the initial approval procedure, later complemented by Supreme Decree No. 54/1994 (Nacional, 1990), and the most recent S.D No. 40/2020 (Ministerio de Bienes Nacionales, 2021), which set compliance requirements based on Euro 5 and Euro 6c standards for emissions of NO_x, CO, particulate matter (PM), and other air pollutants.

- **Colombia** stands out for having one of the most advanced regulatory frameworks for electromobility in Latin America, being one of the countries with the largest set of regulatory parameters implemented. Nevertheless, it has not yet developed a specific standard that regulates the technical operation of electric vehicles (EVs). Despite this gap, Colombia is the only country in this study that has adopted regulatory protocols for direct communication between the EV and the electricity grid, a measure that fosters interoperability and operational efficiency of the system.

  In relation to vehicular energy efficiency, although Law 1955 of 2019 (National Development Plan) (Régimen Legal de Bogotá D.C, 2019) recognizes the importance of promoting energy efficiency in transport, Colombia has not yet issued a specific regulation establishing mandatory standards for this area. The implementation of a specific regulation remains pending. The standardization of charging infrastructure is regulated by Resolution 40123 April 2024 (Ministerio de Minas y Energía, 2024), issued by the Ministry of Mines and Energy (Ministerio de Minas y Energía), which establishes interoperability conditions for public charging stations. This resolution defines the operational requirements, the integration of charging points into the national electricity system, and promotes shared management protocols. In addition, the Mining and Energy Planning Unit (UPME) has published technical guidelines for the design and planning of infrastructure, with differentiated approaches (light vehicles, buses, fleets). These guidelines also establish criteria of continuity and grid density. In terms of vehicle-grid communication standards (V2G/V2B/V2H) Colombia is a pioneer in the region.

  At present, Colombia promotes the use of open protocols such as OCPP (Open Charge Point Protocol) and OCPI (Open Charge Point Interface) to ensure interoperability between charging point operators (CPOs) and mobility service providers (MSPs). Resolution 40123/2024 supports and promotes the implementation of these open protocols as part of the national electric mobility strategy.

  Regarding the reduction of vehicle emissions, Law 1964 of 2019

(Suárez, 2019)—which constitutes the regulatory framework for the promotion of electric mobility—establishes, in its Article 1, the adoption of zero-emission schemes and the reduction of greenhouse gases, through a system of incentives for the use of clean technologies and the progressive replacement of the vehicle fleet powered by fossil fuels.

- **Costa Rica** has developed a broad regulatory framework on electromobility, in which it has only developed standards for communication between the electric vehicle and the electricity grid (V2G/V2H). Nevertheless, the country has not yet implemented specific regulations on vehicle energy efficiency, technical operation of EVs, nor mandatory labeling, which remain pending and represent clear opportunities for regulatory improvement.

  Regarding energy efficiency, Law No. 9518/2018 (Solís, 2018), known as Ley de Incentivos y Promoción del Transporte Eléctrico (Law on Incentives and Promotion of Electric Transport), establishes general public policies aimed at fostering electric transport. Nevertheless, the legislation does not incorporate mandatory minimum energy consumption standards or a vehicle efficiency labeling system. In addition, to date, no supplementary technical regulation has been enacted that requires classification by CO_2 consumption or emissions.

  In relation to the standardization of EVs technical operation, current legislation does not establish specific operational requirements for components such as the battery management system (BMS), on-board chargers (OBC), or vehicle electrical safety standards. Law 9518 and its regulations do not address these aspects in detail, leaving a regulatory gap in the technical approval of EVs. By contrast, charging infrastructure is regulated more clearly. Executive Decree 41642-MINAE/2019 (Sistema Costarricense de Información Jurídica, 2018b) regulates the construction and operation of electric charging centers, requiring that these stations must be operated by electricity distribution companies or through alliances with third parties. In addition, the decree defines minimum guidelines in terms of safety, lighting, measurement and authorization procedures. Complementarily, Costa Rica has adopted a set of national technical standards based on international standards. INTE N121:2020 (INTECO, 2020b), based on the IEC 61851 standard, regulates the minimum technical requirements for the installation of charging stations, including electrical safety, connectors and system compatibility. As well, INTE N120:2020 (INTECO, 2020a) addresses visual standardization and interoperability between cables, connectors, and electric vehicles, promoting a consistent user experience.

  Regarding vehicle emissions reduction, Costa Rica applies the Regulation on the Control of Pollutant Emissions Produced by Internal Combustion Vehicles by Executive Decree No. 39724, which establishes pollutant emission standards.

- **Ecuador** has consolidated a robust regulatory framework in electromobility, which cover specific regulations for energy efficiency, technical operation of electric vehicles (EVs), charging infrastructure and emission reduction. Nevertheless, like Brazil, Ecuador has not yet implemented a vehicle/grid (V2G/V2H) communication standard, which represents a gap in the future system interoperability.

  As for energy efficiency, this is regulated through the Organic Law on Energy Efficiency (Del Pozo, 2019), in force since 2019 and reformed in 2024. Article 11 mandates that, starting in 2025, all vehicles entering the urban and intercity (interparroquial) public transport service on the Ecuadorian mainland must be 100% electric or zero-emission. In addition, Executive Decree No. 238 (Lasso, 2021) complements this law by defining the Electricity Sector Policies aimed at the promotion of charging infrastructure and the decarbonization of land transport. Regarding the standardization of EV technical operation, Decree No. 176 (Dirección Nacional Jurídica, 2024), which implements the Energy Competitiveness Law, establishes regulatory definitions for electric vehicle charging service. This decree regulates the entities authorized to provide these services under the ARCONEL supervision, including guidelines on authorization, operation, security and tariff schemes.

  Regarding charging infrastructure, the Second Reformatory Provision of the Energy Efficiency Law establishes that the commercialization of electric charging services can only be conducted by authorized suppliers, through a contract with electricity distribution companies, and subject to ARCONEL regulations. This entity has issued ARCERNNR Resolution-036/2023 (Agencia de Regulación y control, 2022) and ARCONEL-024/2024 (Agencia de Regulación y control, 2022), which stablish maximum tariff specifications differentiated by charger type (slow, semi-fast, fast), and hourly block, as well as the obligation to include charging stations in the electricity distributors' expansion plans. In addition, Technical Regulation PRTE-162 (INEN, 2017) regulates the technical aspects of charging infrastructure, including connector types, cables, electrical safety conditions, and compatibility labeling, aligned with international standards such as IEC 61851.

In relation to emission reduction, Ecuador applies the technical standard NTE INEN 2204:2002 (INEN, 2002), which establishes maximum permissible limits for carbon monoxide (CO) and hydrocarbon (HC) emissions in light gasoline vehicles, evaluated under minimum and dynamic driving conditions. Since 2017, the Euro 3 standard has been adopted as the minimum requirement for the approval and import of light vehicles, in accordance with the resolution of the Ecuadorian Institute for Standardization (INEN).

- **El Salvador** is in the process of incorporating an energy efficiency law to complement its legal framework for sustainable transport. Nevertheless, the country already has regulations that regulate technical aspects of the electric vehicles (EVs) operation and legislation aimed at reducing polluting emissions. However, other key elements—such as standardization, interoperability and vehicle-grid communication—are still pending development.

  Regarding EV functioning standards, Legislative Decree 738/2020 (Asamblea Legislativa, 2021), which enacted the Law on the Promotion and Incentives for the Import and Use of Electric and Hybrid Vehicles, establishes relevant provisions. Article 13 specifies that vehicles marketed in the country must comply with the technical requirements defined by the manufacturer, thereby guaranteeing minimum safety and quality conditions. Likewise, Article 14 stipulates that all electric charging stations must comply with the regulations and technical standards issued by the General Superintendence of Electricity and Telecommunications (SIGET), covering requirements related to safety, installation, and operation.

  In relation to vehicle emission reduction, El Salvador has a legal basis established in Articles 100 to 102 of the Law on Land Transport, Traffic and Road Safety (Asamblea Legislativa de la República de El Salvador, 2017). These provisions empower the Vice Ministry of Transport and the Environment Division of the National Civil Police (PNC) to establish maximum permissible limits for pollutants such as NO_x, HC, CO, and opacity in gasoline or diesel vehicles. These regulations also require that the authorized car workshops conduct periodic technical inspections and issue annual certificates of compliance. Furthermore, these limits are governed by the Mandatory Salvadoran Standard (NSO) 13.11.03:01, titled as "Emisiones atmosféricas – Fuentes Móviles", approved in 1999 (Santamaría, 1999). This standard establishes measurement procedures, the required testing equipment, and sets maximum emission thresholds for different types of motor vehicles in the country.

- **Guatemala** has made significant progress in electromobility; nevertheless, it still lacks technical standards on the operational functioning of electric vehicles (EVs), as well as communication protocols between the vehicle and the electricity grid. Despite these gaps, the remaining key parameters are addressed within the current national legal framework.

  As for the charging infrastructure, Decree 40-2022 (Law on Incentives for Electric Mobility) (Congreso de la República, 2022), grants authority to the Ministry of Energy and Mines and the National Electric Energy Commission (CNEE) to establish mandatory technical standards. Within this framework, Resolution CNEE-69-2023 (Solórzano, 2023) defines the minimum technical requirements for the design, construction, operation and maintenance of electric charging stations, mandating compliance with the General Electricity Law and the sectoral technical standards in force. Regarding emission reduction from light vehicles, Guatemala has a regulatory framework composed of several instruments:

  - The Law on Traffic on Public Land Roads and Road Safety No.

9078/2012 and its regulations (Governmental Agreement 14-97, under Decree 93-96), authorizes the Ministry of Communications, Infrastructure and Housing (MICIVI) to stablish maximum permitted emission limits for pollutant gases such as CO, HC, NO⍰ and opacity, as well as to define technical procedures for periodic or random vehicle inspections.
- The Regulation for the Control of Pollutant Emissions (April 2016) establishes the mandatory emission testing protocols and specifies the penalties for vehicles that exceed the maximum permissible limits during technical inspections or roadside checks.

In relation to energy efficiency, Governmental Agreement No. 106-2023 formalizes the implementation of the National Energy Efficiency Policy 2023-2050, developed by the Ministry of Energy and Mines. The policy establishes efficiency targets for different sectors, including transport, but does not yet contemplate specific mandatory technical standards for energy consumption or emissions in new or imported vehicles.

- Jamaica currently has an energy efficiency law and regulation designed to reduce pollutant emissions by promoting the use of electric vehicles (EVs). Nevertheless, it is still in the process of developing specific technical standards that regulate both EV operational functioning and the charging infrastructure.

  In terms of energy efficiency, Jamaica's principal national policies are the National Transport Policy (2007) (Ministry of Science, Energy, Telecommunications and Transport, 2023), and the National Energy Policy (2009), which establish as strategic objectives the improvement of vehicle efficiency and the promotion of the use of alternative fuels. Both policies are currently being updated to align with international standards, particularly those promoted by the Global Fuel Economy Initiative (GFEI), marking a significant step toward the adoption of international regulations on energy consumption and fleet efficiency.

  Regarding emission reduction from light vehicles, the document "Motor Vehicle Exhaust Emission Standards", prepared by the National Environment and Planning Agency (NEPA) under the framework of the Road Traffic Act (2018), is currently in the approval phase (Montague, 2018). This document—originally written in 2015—establishes the maximum permissible limits for polluting emissions and proposes the creation of a national program for vehicle inspection and control. Its implementation will be crucial to establish mandatory technical requirements for emissions of CO, NO_x, HC and other compounds, thereby aligning the country with current environmental regulations at the international level.

- **Mexico** is among the countries that have not yet developed specific standards to regulate the technical operation of electric vehicles, nor has stablished protocols for direct communication between the vehicle and the electricity grid (V2G or similar). Nevertheless, the rest of the regulatory components evaluated in this study—such as energy efficiency, charging infrastructure and emission reduction—are incorporated into Mexico's current regulatory framework.
  In terms of energy efficiency, the application of NOM-163-SEMARNAT-ENER-SCFI-2013 (Diario Oficial, 2013) stands out, a mandatory official Mexican standard that sets maximum permissible CO_2 emission limits and minimum energy efficiency (fuel efficiency) levels for new light vehicles (gross vehicle weight ≤ 3,857 kg). This standard demand manufacturers to certify the average consumption and emissions of their vehicle models to the competent environmental authority, ensuring alignment with international practices.

  Regarding the standardization of charging infrastructure, the Energy Regulatory Commission (CRE) has promoted proposals to regulate applicable rates for charging stations, as well as operators (CPOs) and energy contracting modalities. Although there is still no specific mandatory technical standard, approved international protocols such as OCPP and ISO are already in use. In parallel, the Federal Electricity Commission (CFE) promotes the use of independent electric meters to facilitate the installation of domestic and commercial chargers under differentiated tariff conditions.
  In relation to reduce pollutant emissions, Mexico has two key standards:

  - o NOM-044-SEMARNAT-2017 (Secretaría de Gobernación, 2017), which applies to heavy-duty vehicles (gross

weight over 3,857 kg) and diesel engines, which aligns emission limits with international standards equivalent to EPA 2010 or Euro VI, and whose implementation has been mandatory since 2021.
  - NOM-163-SEMARNAT-2013, which applies to new light vehicles, establishes maximum CO_2 emission limits and defines energy performance requirements, thereby promoting a cleaner mobility.

- **Panama** is advancing in the development of an energy efficiency law and the reduction of gas emissions through the use of electric vehicles.

- **Paraguay** similar to other countries in the region, still does not have a standard that enables communication between the electric vehicle and the grid (V2G). Nevertheless, it has developed a robust regulatory framework covering the rest of the parameters considered, including energy efficiency, technical standards, charging infrastructure and emissions regulation.

  In terms of energy efficiency, the National Energy Policy 2050 approved by Decree 2053/2024, and approved by the Executive Branch, establishes among its strategic focus, the improvement of energy efficiency in transport. This policy proposes a roadmap for the future implementation of specific vehicle efficiency standards, although, there are not mandatory standards yet.

  In relation electric vehicle functioning standards, Law No. 6925/2022 (Osorio, 2022), known as "De Incentivos y Promoción del Transporte Eléctrico" (Incentives and Promotion of Electric Transportation), establishes in articles 2 and 4 the authority of the MOPC and related vice-ministries to formulate and apply technical standards and operational regulations applicable to importers, manufacturers, and EVs operators. While these standards are still under regulatory development, the legal basis is already established.

  Regarding the standardization of charging infrastructure, regulation in Asunción is established through Ordinance 204/2019 (Comisiones de Legislación y de Hacienda y Presupuesto, 2019), which regulates the installation of charging stations in public spaces. This ordinance defines technical requirements such as the use of J1772 type connectors, specific cables, anti-vandalism protection, adequate signage, and mandatory technical certifications.

  Concerning the reduction of vehicle emissions, Paraguay has Law No. 5211/2014 (Gómez, 2014) and its regulation under Decree No. 1269/2019, demanding emission control requirements for imported used vehicles, which make mandatory since 2023, to present an emission certificate for customs clearance. In addition, Resolution No. 609/2021 of the Ministry of Environment and Sustainable Development (MADES) establishes the official system for the control of air pollutant emissions, setting permissible limits for CO, NO_x, HC, and particulate matter (PM) generated by mobile sources.

- **Peru** still does not have communication standards between electric vehicles and the electricity grid (V2G). Nevertheless, it does have the rest of the laws and regulations to promote the other key dimensions of electric mobility, including energy efficiency, charging infrastructure, functioning standards and emission reduction policies.

  Regarding electric vehicle functioning standards, Supreme Decree No. 022-2020-EM (Vizcarra, 2020) officially recognizes electric mobility as a public charging service with competitive access. This decree establishes the legal framework for activities related to electric charging and defines the responsibilities of service providers, under the supervision of the Supervisory Agency for Investment in Energy and Mining (OSINERGMIN).

  The standardization of charging infrastructure is regulated by Supreme Decree No. 036-2023-EM (Ministerio de Energía y Minas, 2024), which approves the Regulation for the Installation and Operation of Charging Infrastructure for Electric Mobility. This regulation defines the technical and safety conditions for charging modes 1 to 4, interoperability criteria, and establishes reporting and monitoring obligations to OSINERGMIN. In addition, it specifies the requirements for the authorization, operation and maintenance of charging stations.

Regarding emission reduction, the National Electromobility Plan, promoted since 2021, establishes the guidelines for a progressive transition to electric vehicles, setting clear decarbonization and pollutant reduction targets. This plan proposes measures such as tax reduction for electric vehicles, the implementation of differentiated electricity tariffs, and fleet conversion strategies. Nevertheless, Peru has not yet adopted a mandatory emission regulation aligned with Euro IV, V or VI standards, nor has established maximum emission limits such as CO_2 or NO_X in light vehicles.

In the energy efficiency area, Peru has Law No. 27345 – Law for the Promotion of the Efficient Use of Energy (Congreso de la República, 2000), which declares energy efficiency a matter of national interest and promotes labeling and energy efficiency measures across multiple sectors, including transport. Nevertheless, mandatory vehicle efficiency labeling has not yet been implemented, nor does the country have an official system for the classification of energy consumption in new vehicles.

- **Uruguay** has made significant progress in electromobility and is among the few countries approaching to the incorporation of a standard that enables communication between the electric vehicle and the electricity grid (V2G). Moreover, all other evaluated regulatory parameters are already implemented within its regulatory framework. Regarding energy efficiency, Uruguay has implemented a mandatory labeling system for light vehicles through UNIT 1130:2020 standard (Instituto Uruguayo de Normas Técnicas, 2020), which establishes the energy classification and emission criteria for new vehicles, enabling consumers to compare the vehicle's environmental and energy performance and promoting more sustainable purchasing decisions.

  Regarding the functioning technical standards for EVs, the Electric Urban Mobility Guide (G-MUE) recognizes the application of the UNIT 1234:2020 standard (Ministerio de Industria, Energía y Minería, 2020), which specifies requirements for connectors and conductive charging systems. This standard serves as a reference for the development of future national regulations.

  In the charging infrastructure area, the Regulatory Entity for Energy and Water (URSEA) has established minimum technical requirements for electric vehicle charging installations, in line with the Low Voltage Regulation (RBT). These requirements cover aspects such as installation, wiring, power levels, electrical protections and grid compatibility.

  In relation to emission reduction, the UNIT 1130 energy labelling serves not only as an informational tool, but also as a strategic mechanism to discourage the acquisition of polluting vehicles, aiming to progressively decrease fossil fuel consumption and promote cleaner technologies in the national vehicle fleet.

Table 03. Circulation and reliability

COUNTRY/INCENTIVE	ACCESS TO EXCLUSIVE LANES HOV OR BUS	FREE PREFERENTIAL PARKINGS	EXEMPTION OF VEHICLE RESTRICTIONS	TOLL DISCOUNTS	CHARGING STATIONS
Argentina	✗	✗	✗	✗	—
Bolivia	✗				✓
Brazil	✗	✗	✗	✓	✓
Chile	✗	✓	✓	✓	✓
Colombia	✗	✓	✓	✓	✓
Costa Rica	—	✓	✓	✓	✓
Ecuador	✗	—	✗	✗	✓
El Salvador	✗	✓	✗	✗	
Guatemala	✗	✓	✓	✗	✓
Jamaica	—	—	✗	✗	—
Mexico	✗	✓	✓	✓	✓
Panama	✗	✗	✗	✗	✓
Paraguay	✗	✓	✓	✗	✓
Peru	✗	✓	✓	—	✓
Uruguay	✗	✗	✗	✗	✓

Source: OLADE, Author's elaboration based on information from national statistics

Table 03 presents the incentives proposed, implemented or under development that have facilitated the effective implementation of electric vehicles. In addition, it highlights the measures and benefits provided by governments to guarantee a reliable use of new vehicles.

1. Access to exclusive HOV or Bus lanes: Grants electric vehicles the

right to circulate in lanes designated for buses or high-occupancy vehicles.
2. Exemption from vehicle restriction: Allows electric vehicles to circulate without being affected by policies such as "pico y placa".
3. Exemption from vehicle restriction: Allows electric vehicles to circulate without being affected by policies such as "pico y placa".
4. Toll discounts: Application of reduced or free rates on road tolls for electric vehicles.
5. Charging stations: Availability of Infrastructure for EVs recharge, offering multiple power levels.

Summary by country, from table 03:

- **Bolivia** stands out for being among the countries prioritizing electric charging infrastructure within its incentive framework toward electromobility. Nevertheless, other aspects, such as technical standardization for EV and its communication with the grid, remain underdeveloped.
  In relation to charging stations, Supreme Decree No. 4539/2021 (Arce, 2019), which establishes the national electromobility policy, mandates in its Third Final Provision that the National Electricity Company (ENDE) and its subsidiaries must implement charging stations within a maximum period of 90 days, while also enabling private companies to implement them within 60 days. This decree also establishes tax incentives for cargo equipment, offering reduced or exempt tariffs. In addition, AETN Resolution No. 479/2021 (Sedano Julia, 21) approves the Technical and Safety Regulations for charging facilities, defining technical requirements, operating conditions, and compatible connectors for Vehicle Power Systems (SAVE) and Semi-Fast Charging Points.

  AETN Resolution No. 480/2021 (AETN, 2021) establishes a preferential tariff regime for public electric vehicle charging, with maximum rates differentiated by type of charging: from Bs 1.01/kWh low-speed (slow) charging to Bs 2.15/kWh for high-speed (fast) charging. These rates are subject to periodic adjustments according to the Consumer Price Index (CPI).

- **Brazil**, within its current regulatory framework, has made significant progress in the development of charging infrastructure and the regulation of electric vehicle circulation, although the rest of the parameters related to technical standards or differentiated incentives for EVs remain in limited evolution.

  In relation to toll discounts, Brazil has implemented the Free Flow electronic toll system, regulated by the National Land Transport Agency (ANTT). This system provides discounts on tolls based on the frequency of use of electronic toll collection devices (tags) such as Sem Parar, ConectCar or Veloe. Nevertheless, these benefits are not exclusive to electric vehicles and apply equally to all users who use this system, regardless of vehicle technology.

  Regarding charging infrastructure, Brazil has developed advanced standards and is among the few countries with a specific framework for charging stations. ANEEL Normative Resolution No. 819/2018 (ANEEL, 2018) was the first to establish guidelines for the installation and operation of charging stations, authorizing any legal entity, company or electricity distributor to install charging points without the need for an additional concession. This standard defines technical requirements, connectivity, open communication models, and transparency obligations. Subsequently, ANEEL Normative Resolution No. 1000/2021 (ANNEL, 2021) consolidated and updated these provisions. In Chapter V, it classifies the charging service as an unregulated public service, meaning that charging activities do not affect the domestic electricity tariff and can be freely offered by companies and distributors. Nevertheless, mandatory registration with ANEEL through an electronic form is required, as well as compliance with minimum conditions of security, operation and transparency.

- **Chile**, within the framework of its regulatory progress to promote electromobility, has implemented most of the evaluated incentives, with the exception of access to exclusive lanes, which is not yet included in its current regulations.

  Regarding access to preferential parking, in 2022 the Ministry of Transport and Telecommunications (MTT), together with the Municipality of Providencia, Conecta Logística, CORFO and other actors, launched a pilot plan for smart loading and unloading zones, designating 20 exclusive parking spaces for electric vehicles used in urban delivery. These spaces have clear signage, free of charge, and reserved exclusively for electric logistics vehicles, with their use managed through the TIMIX mobile application. Regarding vehicle restrictions exemptions, Exempt Resolution No. 1555/2020 (Ministerio de transporte, 2020) grants electric and hybrid vehicles an exemption from restrictive measures such as "pico y placa", particularly during episodes of high environmental pollution, allowing them unrestricted circulation in restricted areas and times.

In relation to toll discounts, Supreme Decree No. 262/2024, which regulates tariff harmonization between concessioned highways, does not contemplate specific benefits for electric vehicles. As result, no differentiated rates currently apply to this type of technology within the concession road network.

In terms of charging infrastructure, Chile has a solid technical and regulatory framework. RIC Regulatory Technical Specification No. 15 (Superintendencia de Electricidad y Combustibles, 2024), issued by the Superintendence of Electricity and Fuels (SEC) on October 14, 2020, sets out the technical requirements for charging facilities, including safety conditions, IEC 62196 connectors (types 1 and 2), charging modes, and electromagnetic compatibility. In addition, Supreme Decree No. 12/2022 (Ministerio de energía, 2023), regulated on May 17, 2023, as part of the Interoperability Regulation, requires public charging operators to maintain a digital platform with up-to-date information on location, availability, pricing and connector types. It also mandates the implementation of open communication protocols such as OCPP, and define the roles of operators and owners in accordance with the Electrical Services Regulations. In September 2024, Exempt Resolution No. 27,547 (Ministerio de Energía, 2024), also issued by the SEC, approved the Interoperability Instructions, which establish specific guidelines for data exchange, service continuity and integration among platforms of different charging station operators.

- **Colombia**, like Chile, does not currently have provisions that grant exclusive access to preferential lanes for electric vehicles (EVs). Nevertheless, the country has made significant regulatory advances regarding other infrastructure incentives and measures for preferential circulation. Regarding preferential parking for EVs, Law 1964 of 2019 (Suárez, 2019), in its Article 7, establishes that in municipalities with more than 50,000 inhabitants, both public entities and commercial establishments must allocate at least 2% of their parking spaces exclusively for electric vehicles. These spaces must be clearly marked with a "P" logo and a white plug on a green background to ensure easy visual identification. This provision was regulated by Decree 191 of 2021 (Función Pública, 2021), which amends Decree 1079 of 2015, incorporating technical details on the design, location, and conditions of these parking spaces.

  Regarding exemptions from vehicle restrictions, Article 6 of Law 1964 of 2019 stipulates that electric and zero-emission vehicles are exempt from measures such as “pico y placa”, “dia sin carro” or temporary environmental restrictions, exceptin cases justified by national or local security concerns. This measure promotes the continued use of EVs in highly congested urban areas.

  In relation to toll discounts, Article 5 of the same law grants territorial entities the authority to offer tariff incentives, including tolls and parking lots, to encourage the use of clean technologies. Nevertheless, this authority is not mandatory at the national level, so its application varies across jurisdictions. For instance, the EcoTag program implemented by PASE on the Urban South Highway offers a 20% discount for electric and hybrid vehicles, although it is a private initiative rather than a mandatory national exemption.
  Concerning charging infrastructure, Article 9 of Law 1964 of 2019 establishes that special category municipalities, such as Bogotá, must guarantee the installation of at least five operational fast-charging stations within three years of the law’s entry into force, translating to a minimum of 20 operational stations in Bogotá. This provision reflects a significant regulatory commitment in the development of public charging networks.

- **Costa Rica**, like Colombia and Chile, does not currently provide access to exclusive lanes for electric vehicles (EVs) as part of its incentives. However, it presents a solid regulatory framework in relation to the other benefits linked to electromobility.

Regarding preferential parking, Law No. 9518/2018 (Solís, 2018), in Article 15, authorizes municipal councils to define local policies that exempt EVs from paying parking fees. In addition, the regulation permits the assignment of special spaces in public and private parking lots exclusively for EV use. In addition, Law No. 7717 (Public Parking Regulation Law), amended by Law 9518, incorporates Article 5 bis, which mandates that each public parking facility must have at least one preferential blue space for EVs, ensuring that these spaces do not replace those reserved for people with disabilities.

In terms of exemption from vehicle restrictions, Article 14 of Law 9518 stipulates that electric vehicles displaying the official badge of the Ministry of Environment and Energy (MINAE) are exempt from compliance with measures such as the "pico y placa" in the Metropolitan Area, in accordance with regulations issued by the Ministry of Public Works and Transport (MOPT). This benefit encourages greater EV circulation in highly congested areas without penalty.

In relation to toll discounts, Article 17 of the same law, establishes that highway concessionaires and parking operators may offer preferential rates for EVs, as long as such rates are defined by local agreements or provisions. Nevertheless, there is no automatic or mandatory exemption at the national level, so its application depends on the discretion of each concessionaire. Regarding charging infrastructure, Article 19 of Law 9518 authorizes public institutions, companies and municipalities to invest in the installation of electric charging stations and exclusive parking for EVs. This provision was reinforced by Executive Decree 43641-H-MINAE-2022 MOPT (MINAE, 2022), which regulates the procedures for tax exemption and defines some basic technical requirements. Nevertheless, the issuance of specific regulations standardizing the communication, interoperability, and approval protocols for these charging stations is still pending.

- **Ecuador**, in the context of this comparative table, lacks most of the parameters established regarding incentives and interoperability for electromobility. Nevertheless, it presents a significant regulatory advance in terms of electric charging infrastructure. In this context, Executive Decree No. 238/2021 (Lasso, 2021), which defines the national energy policy, establishes in its Second Reformatory Provision, Article 43, the legal basis for providing electric vehicle charging services. This article authorizes natural or legal persons to offer such services through contracts with electricity distribution companies, provided they comply with the technical and tariff regulations issued by ARCONEL (Agency for Regulation and Control of Energy and Non-Renewable Natural Resources). In turn, ARCONEL Regulation No. ARCERNNR-036/2023 and ARCONEL Resolution-024/2024 (Agencia de Regulación y Control, 2022) reinforce this framework by stablishing specific obligations for charging service providers, including:
  - Formal contracts with electricity distributors.
  - Minimum technical standards for infrastructure.
  - Maximum tariff per kWh applicable to public charging.
  - Requirements for the expansion of charging stations as part of regional electricity plans.

  In addition, the Ecuadorian Technical Regulation PRTE-162 (issued by the INEN) (INEN, 2017) defines the mandatory technical characteristics of electric charging systems, including:
  - Connector types and compatibility.
  - Charger and wiring specifications.
  - Electrical safety and security requirements.
  - Classification of charging modes (modes 1 to 4).
  - Minimum recommended power levels for each modality.

- **El Salvador** has advanced in the implementation of additional incentives for electromobility, particularly in preferential parking areas and the regulation of charging stations for electric vehicles (EVs).

  Regarding preferential parking incentives, Article 12 of the Law of Promotion and Incentives for the Import and Use of Electric and Hybrid Vehicles (Legislative Decree No. 738/2020) (Asamblea Legislativa, 2021) includes specific provisions that guarantee this benefit:
  - Electric and plug-in hybrid vehicles are entitled to free parking in the designated "parqueos verdes" (green parking lots), located in public or private spaces (such as shopping centers, super-

markets or institutions).
- The location of these spaces must have clear signage and cannot substitute spaces reserved for people with disabilities.
- Unauthorized use of these spaces is subject to penalties, with fines equivalent to fifteen days of the current minimum wage in the commercial or service sector.

In relation to charging stations, the same Law No. 738/2020 establishes Articles 13, 14 and 15 a comprehensive regulatory framework:

  - Article 14 stipulates that charging centers can be installed in public and private environments, but must comply with the technical standards established by the General Superintendence of Electricity and Telecommunications (SIGET). Furthermore, operators are required to provide public and visible information on prices, estimated charging times and location.
  - Article 13 establishes the obligations for importers and distributors of electric vehicles, requiring them to guarantee technical service and the availability of spare parts, as well as to collaborate with public policies for the implementation of charging infrastructure.
  - Article 15 grants a five-year exemption from Income Tax to natural or legal persons that provide EV charging services, which constitutes a direct incentive to the expansion of this type of infrastructure.

In summary, El Salvador presents a favorable environment for the development of electromobility supported by concrete incentives in infrastructure and tax benefits. Nevertheless, gaps remain in the technical standardization of vehicles and grid-vehicle interoperability protocols.

- **Guatemala** presents relevant regulatory advances in charging infrastructure and in defining conditions for the provision of electric vehicle (EV) charging services.

Regarding preferential parking, the Law on Incentives for Electric Mobility (Decree 40-2022) (Congreso de la República, 2022) encourages the use of EVs through tax and operational incentives; Nevertheless, it does not contemplate specific provisions requiring the allocation of exclusive or free spaces for electric vehicles, either nationally or at the municipal level.

In relation to exemptions for vehicle restrictions, Decree 40-2022 does not contemplate articles that allow EVs to bypass measures such as "pico y placa", environmental zones limitations, or circulation restrictions. Consequently, there are currently no regulatory benefits granting operational priority to EVs within Guatemala's road system.

Regarding charging infrastructure, Article 13 and subsequent of Decree 40-2022 regulate the provision of the electric charging service, allowing natural or legal persons to offer this service without requiring a prior electricity contract, under the supervision of the National Electric Energy Commission (CNEE). It is established that all services must comply with the technical requirements issued by the CNEE, ensuring safety and operational standardization.

- **Mexico**, although it does not have all the incentives related to EV circulation and general operability, has implemented significant measures in areas of preferential parking, vehicle exemptions, and the regulation of charging infrastructure.

Regarding preferential or free parking, the Ley de Movilidad de la Ciudad de México (Mexico City Mobility Law) and the Reglamento de Tránsito de la CDMX (Mexico City Traffic Regulation) (Article 35) establish the requirement for public and private parking lots to reserve exclusive spaces for electric and hybrid vehicles. These spaces must have clear signage in accordance with current regulations, favoring the accessibility of EVs in urban centers. Regarding exemption from vehicle restrictions, electric vehicles registered in Mexico City can access the "Exempt" Vehicle Verification Hologram, which excludes them from the "Hoy No Circula" program and mandatory vehicle verifications, granting them unrestricted circulation even during environmental contingencies or emission restrictions.

In relation to charging stations, the Energy Regulatory Commission (CRE) issued Agreement A/108/2024, which approves the General Administrative Provisions (DACG) for the integration of electric vehicle charging infrastructure. This regulatory framework establishes:

- ○ Formal connection to the National Electric System (SEN);
- ○ The creation of a public digital platform, providing transparency and real-time information on the location, availability, and technical specifications of charging points.
- ○ Interoperability through the adoption of open communication protocols, such as OCPP (Open Charge Point Protocol).
- ○ And the definition of minimum technical requirements for the charging service providers, ensuring safety, standardization and operational reliability.

- **Panama** stands out for having—among the incentives applicable to the circulation and operability of electric vehicles (EVs)—, only the regulation of charging stations, which is structured under a comprehensive regulatory approach.

  Law 295 of 2022 (Asamblea Nacional, 2022) establishes the Política Nacional de Movilidad en el Transporte Terrestre (National Policy for Electric Mobility in Land Transport), formally defining key concepts such as electric charging, electric vehicle, and charging station in articles 1 to 3. Chapter III (Articles 12 to 18) mandates municipal governments to require the installation of charging stations in new residential, commercial or institutional infrastructure projects. In addition, the use of renewable energy sources to supply these stations is authorized. Article 15 allows natural and legal persons to provide electric charging services, contemplating tax exemptions and establishing that the technical and operational regulation will be overseen by the National Public Services Authority (ASEP). In addition, Executive Decree No. 51 of February 15, 2023, which regulates Law 295, develops specific aspects for the implementation and operation of charging stations, including:

  - ○ Mandatory signage for spaces designated as "parqueos verdes" for EVs, in accordance with the Electrical Installations Regulation (RIE) and the technical provisions of the Panama Fire Department.
  - ○ Electrical safety requirements and individualized measurement of electricity consumption, requiring that each charging point has a dedicated meter to record the consumption in kWh per EV, with physical separation of the electric system according to the operator category.
  - ○ Mandatory adoption of interoperability protocols, such as OCPP 1.6 or equivalent versions, to guarantee compatibility between operators and management platforms.
  - ○ Mandatory digital registration with ASEP via a single authorized platform, with technical supervision by the National Energy Secretariat, ensuring regulatory compliance and operational traceability of the charging service.

- **Paraguay** has advanced in promoting electromobility through a series of regulatory incentives, particularly in the areas of preferential parking, circulation, and the implementation of charging infrastructure for electric vehicles (EVs).

  Regarding preferential parking, Law No. 6925/2022 (Osorio, 2022) – Incentives and Promotion of Electric Transportation, establishes specific provisions:

  - ○ Article 14 provides that municipalities shall exempt electric vehicles, properly identified with an official mark issued by the Ministry of Public Works and Communications (MOPC), from paying any parking fees. This measure is valid for ten years from the law's publication.
    Article 15 establishes the obligation for public and private parking lots (shopping centers, hospitals, universities, etc.) to reserve special spaces labeled as "parqueos verdes" for EVs, and ensuring that these spaces do not replace those designated for people with disabilities.

  In relation to vehicle exemption, although Law 6925/2022 does not explicitly contemplate benefits such as the exemption from "pico y placa" restrictions, it establishes indirect mobility facilities through the following articles:
  - ○ Article 13 establishes the exemption for electric vehicles from paying the plate tax.
  - ○ Article 16 empowers public entities to grant mobility facilities
  - ○ for electric vehicles that belong to institutional fleets.

  These provisions give EVs an operational advantage, allowing them to receive prioritization or preferential treatment within urban mobility schemes, even without direct mention of specific restrictions. Regarding charging stations, the regulations establish a mandatory territorial planning and technical operating standards:

- Article 30 establishes that the MOPC must guarantee the existence of at least two fast charging stations in every municipality with more than 60,000 inhabitants, allowing both public and private infrastructure to be accessible to all users.
- Article 32 requires the MOPC and the National Electricity Administration (ANDE) to ensure the construction and operation of charging centers, under criteria of compatibility with international standards. It also stipulates that charging stations must be installed every 80 km on national routes, ensuring coverage across interurban road corridors.
- Article 4 empowers the MOPC to issue specific technical regulations for the installation, operation and supervision of charging stations, in coordination with the competent regulatory entities.

- **Peru**, like Paraguay, has made regulatory progress for charging stations, although it does not currently contemplate incentives related to preferential parking or vehicle exemptions.

  In relation to preferential parking, Thematic Report No. 89/2024-2025 of the Congress of the Republic, in its comparative legislation section, concludes that there are no national or municipal regulations in force mandating public or private establishments to reserve exclusive parking spaces for electric or hybrids vehicles. The lack of incentives reveals a gap in local public policy for sustainable mobility.

  Regarding vehicle restriction, the same parliamentary report indicates that no provisions have been established that exempt EVs from measures such as "pico y placa", "día sin carro", or temporary environmental restrictions, which are still applied broadly across various jurisdictions of the country. Although there are law drafts that seek to incorporate these exemptions as incentives for electromobility, they have not yet been approved or implemented in the national legal framework.

  In the charging infrastructure area, Peru has made significant regulatory progress. Supreme Decree No. 036-2023-EM (Ministerio de Energía y Minas, 2024), approves the Regulations for the Installation and Operation of Charging Infrastructure for Electric Vehicles, which establishes:
  - Station classification: distinguishes between residential, public open access stations, and those intended for institutional or private fleets.
  - Technical and electrical safety requirements: including installation conditions, interoperability, minimum power levels and protections, in line with international standards.
  - Obligation to register and report to OSINERGMIN, the supervisory body of the energy sector.

  Likewise, in 2020, the Ministry of Energy and Mines (MINEM) declared electromobility a policy of national interest, which has led to strategic plans aimed at:
  - Promote the progressive massification of public charging infrastructure.
  - Stimulate private and public-private investments in the sector.
  - Implement pilot projects in Metropolitan Lima and other key cities in the country, as part of a gradual expansion model.

- **Uruguay**, stands out for its consolidated regulatory framework governing electric vehicle (EV) charging infrastructure, this being the main operational incentive implemented in the country. Current regulation establish that all public charging infrastructure must comply with the requirements of the Low Voltage Regulation (Reglamento de Baja Tension/RBT) and relevant municipal building codes, as stipulated by the Ministry of Industry, Energy and Mining (MIEM). This institution leads the national energy policy regarding electric mobility. In addition, the Regulatory Entity for Energy and Water (URSEA) serve as a technical regulatory entity, defining the specific electrical conditions for charging facilities through Chapter XXX of the RBT. This chapter outlines the necessary safety, connection, protections and electrical capacity criteria required for public and private stations. In 2022, the MIEM issued a technical resolution stablishing guidelines to guarantee the interoperability of charging stations. The resolution mandates the use of open communication protocols, highlighting the Open Charge Point Protocol

(OCPP) as a mandatory standard to ensure compatibility between stations, operators and vehicles, supporting the development of a nationally interoperable network. In addition, Uruguay has adopted the UNIT 1234:2020 technical standard, which is based on European conductive charging standards. This regulation addresses key aspects such as:

- Supported connector types.
- Permissible power capacities.
- Electromagnetic compatibility requirements.
- Minimum installation and operational safety conditions.

Table 04. Other types of incentives

COUNTRY/INCENTIVE	LEASING	ENVIRONMENTAL COMMITMENTS' AGREEMENTS
Argentina	✗	—
Bolivia		✓
Brazil	✗	✓
Chile	✗	✓
Colombia	✓	—
Costa Rica	✓	✓
Ecuador	✗	✓
El Salvador		✓
Guatemala		✓
Jamaica	✓	✓
Mexico	✗	✓
Panama	✗	✓
Paraguay	✓	✓
Peru		✓
Uruguay	✗	✓

Source: OLADE, Author's elaboration based on information from national statistics

Table 04 outlines parameters that have enabled most countries in the region to take environmental agreements into account, as any change in the energy matrix require a detailed analysis. Likewise, the table covers the study of electric vehicles operating under leasing arrangements.

1. Leasing: A modality of acquiring electric vehicles through medium

or long-term leasing, with an option to purchase at the end of the contract (financial leasing) or without it (operating leasing).

2. Environmental commitment agreements: Formal pacts between governments, companies, institutions, or countries to reduce their environmental impact through voluntary or regulated actions, such as the adoption of electric vehicles.

Summary by country, from Table 04:

- In **Colombia**, financial and operational leasing for electric vehicles have experienced significant growth, particularly in the fleet segment for urban deliveries. Although there is currently no specific law that regulates this mechanism for electric vehicles, various private sector entities have developed attractive leasing schemes, leveraging the tax benefits contemplated in Decree 1964 of 2019 (Suárez, 2019). A prominent example is the company Arval (ARVAL, 2025), which provides leasing solutions enabling companies to access income tax deductions, provided they comply with current regulatory requirements. This type of financial instrument has proven to be an effective mean of promoting electric vehicle adoption, by reducing initial investment costs and promoting fleet renewal under sustainability criteria.

- **Costa Rica** offers financial products such as rental or flexible leasing options for electric vehicles on the market, which facilitate access to this technology without requiring an outright purchase. A representative example is Total Fleet Costa Rica (TOTAL Fleet, 2025), which offers mobility services through operating leasing schemes. Although no specific legislation currently regulates these instruments for electric vehicles, the financial and commercial environment has enabled their development as a viable alternative for companies and individuals interested in the transition to more sustainable mobility.
  Regarding environmental commitments, Costa Rica actively participates in international climate agreements, including the Conferences of the Parties (COP). Its National Electric Mobility Policy includes clear targets for the electrification of public transport, in line with the Sustainable Development Goals (SDGs) and the country's ambitious goal of reducing the transport sector emissions by a 20% by 2050 (MINAE, 2020).

- **Bolivia**, through its participation in the National Electric Mobility Strategy (Estrategia Nacional de Movilidad Eléctrica/ENME) (GIZ Bolivia, 2024a), presents a structural commitment to decarbonizing the transport sector.
  Within the framework of its international climate commitments, Bolivia has proposed a 22% reduction in its greenhouse gas emissions by 2030, connecting this goal to the promotion and gradual implementation of electric mobility nationwide (GIZ Bolivia, 2024b).

- **Brazil** has companies such as General Motors that have signed the UN Global Compact, committing to the electrification of sustainable fleets and supply chains (Stuckert, 2024), (Centeno, 2024).

- **Chile** has the Public-Private Agreement for Electromobility, signed since 2021 by the government, energy and automotives companies, academic institutions and civil organizations (Ministerio de Energía, 2021), which establishes a joint roadmap to accelerate the transition toward sustainable mobility. This agreement contemplates specific targets to be met until 2025, focused on the deployment of charging infrastructure, system interoperability, and specialized technical training to consolidate national capacities around electromobility (ABB, 2021), (Ministerio de Energía, 2021b).

- **Ecuador** promotes the transition to sustainable mobility through the E-MOVILIZA project (E-MOVILIZA, 2025), led by the United Nations Development Programme (UNDP). This initiative reflects an institutional and public commitment-to accelerate the adoption of electromobility with an inclusive and equitable approach, prioritizing accessibility, sustainability and social justice. In addition, Ecuador actively participates in spaces such as the Technical Table on Electric Mobility (Mesa Técnica de Movilidad Eléctrica) of the Institute of Geological and Energy Research (Instituto de Investigación Geológico y energético/IIGE), where integrated strategies for scrapping polluting vehicles and the promotion of clean technologies in the transport sector are addressed (Instituto de Investigación Geológico y Energético, 2024).

- **El Salvador** has launched its Strategy for the Promotion of Electromobility, framed within the Economic Take-Off Plan promoted by the National Government. The strategy establishes concrete commitments aimed at the progressive development of charging infrastructure, the implementation of tax incentives and the promotion of electric vehicles adoption. The plan aims not only to strengthen the transport sector, but also to contribute to environmental sustainability and the modernization of the vehicle fleet, aligning its objectives with regional and global decarbonization trends. (Murillo, 2020))

- **Guatemala** is in the process of formulating a National Electric Mobility Strategy in collaboration with the United Nations Environment Programme (UNEP) and the Ministry of Environment and Natural Resources (Ministerio de Ambiente y Recursos Naturales/MARN). This initiative includes inter-institutional commitments aimed at incorporating electromobility as a central pillar of national climate policy, aiming to align emission reduction objectives with the development of a sustainable and resilient transport system (UNEP, 2023).

- **Jamaica** is developing the leasing and renting of electric vehicles, particularly in corporate fleets and electric taxi services in urban areas such as Kingston (Ministry of Science, Energy, Telecommunications and Transport, 2023). Nevertheless, despite the fact that this practice has progressively expanded, there is no specific regulation that formally regulates it, remaining as a solution promoted by the private sector.

  Regarding environmental commitments, Jamaica is making progress in the implementation of vehicle emission standards within the regulatory framework of the Road Traffic Act (2018) (Montague, 2018). In addition, the adoption of future "Motor Vehicle Exhaust Emission Standards", developed by the National Environmental Planning Agency (NEPA), is planned (Reynolds-Baker, 2014). These efforts align with commitments made at international climate conferences (COPs), within the framework of a national strategy to mitigate emissions from the transport sector.

- **Mexico** through the Energy Regulatory Commission (CRE) and the Federal Government, has issued provisions aligned with national environmental commitments to electrify transportation and the development of interoperable charging infrastructure. At present, it is in the process of preparing and adopting Official technical Mexican Standards (NOMs) that will establish specific requirements to guarantee the safety, efficiency, and compatibility of charging systems nationwide (Zarco, 2024), (Hernández, 2024).

- **Panama**, through Law No. 295 of 2022 (National Assembly, 2022), demonstrates its commitment to climate action by establishing a national electric mobility policy, which promotes charging infrastructure through tax incentives, tax exemptions, and state planning requirements for new urban projects. This law is operationalized by Executive Decree No. 51 of 2023 (Ministerio de la Presidencia, 2023), which specifies the technical, safety, and interoperability requirements for electric charging stations, thereby consolidating the regulatory framework for an orderly transition to sustainable transport.

- **Paraguay** has electric vehicle leasing mainly for companies through private financing schemes, although no specific regulation currently governs this practice (Sudameris, s.f.). The market is expanding, driven by the growing corporate interest in sustainable mobility solutions.
  Regarding environmental commitments, Law No. 6925/2022 (Osorio, 2022) establishes specific objectives for the electrification of transport and the reduction of CO_2 emissions, promoting the adoption of electric vehicles in both public fleets and public leasing services. The regulation also mandates the development of charging infrastructure, with planning and regulation oversees by the Ministry of Public Works and Communications (MOPC) and the National Electricity Administration (ANDE).

- **Peru**, through Supreme Decree No. 022-2020-EM (Vizcarra, 2020), recognizes electromobility as a matter of national interest, establishing goals for the progressive electrification of public fleets. This framework is complemented by Supreme Decree No. 036-2023-EM (Diario Oficial del Bicentenario, 2023), which approves the Regulations for the Installation and Operation of Charging Infrastructure, consolidating the technical, safety, and interoperability conditions required for public charging stations.

- **Uruguay** has committed to achieve carbon neutrality by 2050 as part of its national strategy against climate change. Within this framework, it has promoted public-private agreements in electromobility, bringing together government and private sector actors with the aim of deploying charging infrastructure, promote specialized technical training, and progressively reduce emissions from the transport sector in a coordinated manner (SNRCC, 2021).

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Financing for Sustainable Mobility

Sustainable mobility represents a fundamental pillar in the just energy transition that the countries of Latin America and the Caribbean (LAC) are going through. From an energy, social and environmental perspective, transport systems must be transformed to reduce their dependence on fossil fuels, mitigate greenhouse gas (GHG) emissions, improve energy use efficiency and ensure equitable access to transport. In this framework, financing plays a central role as an enabler of the technical, urban, technological and socio-cultural solutions necessary to achieve low-carbon, efficient and accessible urban and regional mobility.

What do we mean by sustainable mobility?

Sustainable mobility is defined as that which allows the needs of people and goods to be met without compromising the well-being of future generations. It involves ensuring the environmental, social and economic sustainability of the transport system. This translates to:

- Reducting polluting emissions and energy consumption.
- Promoting equity in access to means of transport.
- Promoting active mobility (walking, cycling) and electrification of motorised transport.
- Integration of urban and transport policies under a focus on efficiency and social cohesion.

According to the International Energy Agency (IEA, 2024), achieving sustainable transport requires a comprehensive approach that includes efficient vehicles, clean energy, adequate infrastructure and a change in mobility patterns. The mere replacement of fossil-based energy sources by other energy sources is not a sufficient condition for meeting the objective, but urban planning focused on sustainability, modal distribution and intelligent management of transport demand is also necessary.

Types and Models of Electric Vehicle Acquisition

Electric vehicles (EVs) are a key element in the decarbonisation of the transport sector. To facilitate their mass incorporation, it is necessary to promote acquisition schemes that reduce the initial barriers to entry. Existing models include:

- **Direct Purchasing with Subsidies**: Governments may provide direct subsidies to individuals, corporate fleets, or public transportation to reduce the cost of acquiring EVs.
- **Leasing:** allows the use of the vehicle through monthly payments, facilitating its periodic renewal and technological update.
- **"Vehicle as a service" models:** schemes such as carsharing or the use of technology platforms for shared mobility integrate EVs without the need for individual ownership.
- **Aggregate public procurement:** allows governments or multilateral entities to negotiate preferential prices for large procurement volumes, as has been demonstrated in the case of electric bus fleets.

These models require powerful regulatory frameworks and diversified funding sources. In addition, they must consider the entire life cycle of the vehicle, including its energy efficiency, maintenance and final disposal. Mainly, the Total Cost of Ownership (TCO) should be addressed as a variable to be analyzed when making comparisons between various types of vehicles.

Funding needs to move towards sustainable mobility

The transition to sustainable mobility requires significant investments in three key areas::

- **Infrastructure:** construction of priority corridors for public transport, cycling networks, charging stations for EVs, modernization of the road system, smart traffic lights and integrated mobility solutions.
- **Rolling stock:** renewal of public transport fleets (buses, trams, trains) with low or zero emission technologies. This also includes the promotion of private fleets, taxis, SMEs and platform services that opt for electric or hybrid alternatives.
- **Cultural change and training:** financing of awareness campaigns, technical training, mobility studies, urban and mobility planning with citizen participation and fair transition measures that facilitate the acceptance of new technologies and forms of mobility.

Shared mobility also requires funding, as it modifies the traditional logics of transport by reducing the number of vehicles in circulation and encouraging a more rational use of resources.

Actors funding the transition to sustainable mobility

National states:

Central governments play a crucial role in enabling financial mechanisms that stimulate technological and cultural change in the sector. Featured tools include:

- Reduction or exemption of taxes for the acquisition of EVs and associated equipment.
- Allocation of direct subsidies for low-emission public or private transport.
- Implementation of carbon or vehicle congestion taxes to finance sustainable systems.
- Redirection of public spending towards green infrastructure.
- Use of urban planning instruments such as urban capital gains or value capture due to improvements in transport.

Subnational governments::

Cities and provinces also have relevant funding tools::

- Reduction of traffic fees for sustainable vehicles.
- Differentiated parking charges depending on the type of vehicle or area.
- Collection for use of public space (e.g. parking lots on public roads) to finance buses or cycle paths.
- Compensation mechanisms for greater urban uses around transport infrastructure.

Institutional investors, development banks and multilateral agencies:

- They provide long-term financing for major road infrastructure works, mass transit systems, charging stations and associated power grids.
- They structure funds for the acquisition of low-emission rolling stock, which allows reducing the total cost of ownership (TCO) and mitigating the initial investment effort.
- They support the generation of carbon bond markets and financing schemes linked to results (Results-Based Finance).
- They implement solutions to reduce investment risks through guarantees, blended finance and green funds.

Commercial banks, suppliers and energy service companies (ESCOs):

- They grant loans on preferential terms to transport operators and end users.
- They develop payment for savings models, in which the cost of financing is offset by the energy savings generated.
- They participate in “electromobility as a service” schemes that integrate financing, maintenance, and energy supply.

Funding and Financing Public Transportation in LAC: A Regional Priority

Efficient and accessible public transport is the backbone of sustainable mobility in Latin America and the Caribbean. Without it, it is not possible to guarantee the right to the city, reduce dependence on the private car or achieve regional climate and energy goals.

Currently, transport is responsible for approximately 40% of CO2 emissions in the region (IDB, 2023). In addition, it is estimated that road congestion costs up to 1% of annual GDP in cities such as Buenos Aires, Sao Paulo or Mexico City. More than 150 million people live in urban areas with pollution levels that exceed the limits recommended by the WHO (CAF, 2024).

Faced with this scenario, funding and financing strategies should focus on::

- Efficient use of subsidies, prioritizing service improvement and access for vulnerable populations.
- Generation of new sources of payment, such as parking, congestion or pollution taxes, and mechanisms for capturing urban valuations.
- Diversification of financial instruments: multilateral credits, green bonds, concessional financing, risk mitigation instruments.
- Strengthening of local capacities for investment planning, management and evaluation.

Experiences such as those in Santiago de Chile, Mexico City and Bogotá show that financial innovation can accelerate the electrification of public transport, reduce costs and improve service quality.

Final considerations and need for future studies

Financing for sustainable mobility represents an ever-evolving field. The economic, technological and political conditions of the LAC countries demand adapted strategies and innovative solutions that ensure the technical and financial viability of the projects. It is important to emphasize that there are no unique solutions, but that each society needs a mix of solutions appropriate to its possibilities, needs and cultural particularities.

It is important to continue making progress in studies on the energy costs of transport, efficiency compared between modes, the role of renewable energies and energy storage technologies and the analysis of tariff schemes and total costs of ownership of vehicles by type of motorization. Likewise, it is necessary to explore the roles of digitization, artificial intelligence and Big Data analysis for transport management with operational and energy efficiency.

In the next edition of the Mobility White Paper, this chapter will be expanded with new evidence, energy indicators and case studies to more accurately assess the impacts of financing on the performance of the transport sector. The analysis of just transition mechanisms, the inclusion of the gender perspective and citizen participation will also be addressed to enrich the understanding of the phenomenon.

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Lithium batteries and critical minerals in LAC

Introduction

Global context of electric mobility

Over the past decade, electric mobility has emerged as one of the most effective strategies for decarbonizing the transport sector, which accounts for around 25% of global CO_2 emissions. Its adoption is driven by a convergence of technological, economic, environmental and regulatory factors that shape a new paradigm in the global energy transition.

From a technological perspective, advances in rechargeable batteries—particularly lithium-ion—have significantly increased energy density while reducing costs per kilowatt-hour, thereby improving the range and competitiveness of electric vehicles (EVs). These advances are complemented by the development of intelligent energy management systems, fast charging infrastructure and their integration with smart grids.

On the economic sphere, the global EV market has experienced an accelerated growth, surpassing 17 million units sold in 2024. This dynamism has stimulated a reconfiguration of global value chains, with massive investments in large-scale battery factories, the extraction and processing of critical minerals, and digital platforms for the management and monitoring of electric fleets.

From an environmental perspective, EVs represent an effective tool to improve urban air quality and reduce reliance on fossil fuels. Their contribution to climate change mitigation becomes particularly significant when they are integrated within electricity matrices with a high participation of renewable sources.

On the regulatory plan, multiple governments have adopted incentive policies and binding targets for the electrification of the vehicle fleet. The European Union, for instance, has legislated a ban on the sale of internal combustion engine vehicles from 2035. In parallel, countries such as Canada, India, Chile and the United Kingdom have adopted similar timelines, supported by regulatory frameworks, tax exemptions, and investment in charging infrastructure.

Together, these dynamics are redefining the industrial and energy landscape of the 21st century. The capacity to develop and control battery technology has become a strategic component for economic competitiveness and energy security, and the fulfilment of global climate commitments.

Importance of batteries in electric vehicles

Batteries are the core component in the architecture of electric vehicles (EVs), as they largely determine performance, range, cost, and commercial viability. Their role extends beyond energy storage, but also as a strategic factor in the industrial, energy and environmental development of electric mobility.

From a technical perspective, the battery acts as the functional equivalent of the thermal propulsion system in conventional vehicles. Its energy capacity (expressed in kWh), gravimetric density (Wh/kg), and specific power directly influence the vehicle's range, acceleration and dynamic behavior. Likewise, conversion efficiency, charge/discharge rate, thermal stability, and lifespan are key variables in the design of electric platforms.

In economic terms, the battery currently represents between 30% and 40% of the total cost of an electric vehicle. Although its price has fallen dramatically over the past decade—from more than USD 1,000/kWh in 2010 to under USD 150/kWh in 2024—the battery remains a determining factor in the competitiveness of EVs relative to internal combustion equivalents. Cost reductions through economies of scale, vertical integration, and advances in materials and manufacturing processes remains a central priority for manufacturers.

From an environmental perspective, batteries play a dual role. First, they enable significant reductions in local and global emissions during vehicle operation. Furthermore, it concentrates the main impacts of the EV life cycle in its production phase, due to the high energy intensity involved and the use of critical materials such as lithium, cobalt, nickel and graphite. The development of new chemical combinations, efficient recycling, and circular design are essential elements to ensure a truly sustainable energy transition.

To conclude, at a strategic level, batteries have acquired growing geopolitical relevance, given their association with global supply chains, energy security, and technological leadership. The capacity to design, manufacture, and manage advanced storage systems has become a critical component of the industrial sovereignty of countries that are committed to electric mobility as a vector of economic development and innovation.

Objectives and scope

The purpose of this document is to provide a comprehensively analysis of the current state and future prospects of battery technologies for electric vehicles, considering their central role in the transition toward sustainable mobility.

In particular, it aims to:

Examine the main types of batteries used in electric vehicles, their technical characteristics, and their level of technological maturity.

Evaluate the operational performance of batteries in terms of range, charging times, energy efficiency, and life cycle.

Identify the challenges linked to the extraction of critical materials, the environmental footprint across the life cycle, recycling and circular economy strategies.

Analyze the economic, geopolitical, and regulatory factors influencing the evolution of the battery market, including price trends, supply chains, and public policies.

Explore emerging innovations in energy storage and their potential to enhance the scalability, sustainability and resilience of the sector.

The structure of the document combines a technical-scientific review with policy analysis and market data, with the aim of providing useful inputs for policymakers, companies in the energy and automotive sector, and researchers, as well as for other public, private and civil society actors involved in the electric mobility value chain.

Types of Batteries for Electric Vehicles

Lithium-ion (Li-ion) batteries

Lithium-ion (Li-ion) batteries are currently the dominant technology in the electric vehicle market due to their high energy density, efficient charge-discharge, and strong durability. These batteries use lithium compounds in the anode and cathode, along with a liquid electrolyte to transport the lithium ions during the charging and discharging process.

One key advantage is the ratio between stored energy and weight, which allows the vehicles to achieve ranges of up to 600 km or more on a single charge. In addition, they exhibit low self-discharge, which enhances their efficiency during storage.

There are different chemistries inside Li-ion batteries:

NMC (Nickel-Manganese-Cobalt): Balances energy, safety, and durability; commonly used in vehicles such as the Chevrolet Bolt.

NCA (Nickel-Cobalt-Aluminum): Offer higher energy density and is used by Tesla, but requires advanced cooling systems.

LFP (Lithium Iron Phosphate): Safer and more cost-effective, though with lower energy density; popular in urban mobility models.

The challenges of Li-ion batteries include dependence on critical materials such as cobalt, whose extraction has ethical and environmental implications. Their performance can be affected by extreme temperatures.

Nevertheless, constant research has made it possible to improve its life cycle (up to 2000-3000 complete cycles), significantly reduce costs and develop variants with lower environmental impact. Li-ion batteries will continue to play a leading role in the transition to electric mobility for at least the next decade.

Lithium Iron Phosphate batteries ($LiFePO_4$)

Lithium Iron Phosphate ($LiFePO_4$) batteries, a subcategory of lithium-ion batteries, have become a solid choice in e-mobility applications, particularly in buses, urban vehicles and short-haul fleets. their chemical composition replaces cobalt and nickel with iron and phosphorus, significantly reducing costs and improving the sustainability of the production process.

A key advantage of $LiFePO_4$ batteries is their high thermal and chemical stability. They are less prone to overheating, fire, or explosions, making them among the safest options on the market. In addition, they have a higher lifespan, with the capacity to withstand more than 3000 charge and discharge cycles with minimal capacity loss.

Although its energy density (approximately 90–160 Wh/kg) is lower compared to other chemistries such as NMC or NCA, this is offset by its reliability, low cost, and safety. This feature makes them ideal for vehicles that do not require extremely long ranges, but do require high durability and operational efficiency.

Additional advantages include lower sensitivity to extreme temperatures, low self-discharge, and a more stable behavior throughout the life cycle. Nevertheless, its lower energy density represents a limitation for applications that demand high range or space and weight restrictions.

Currently, manufacturers such as BYD and Tesla (in some China-produced models) are using LFP/$LiFePO_4$ batteries due to their low cost, reliability, and the greater availability of less conflicting raw materials. Its adoption is on the rise, especially in emerging markets and commercial fleet segments.

Solid State Batteries

Solid state batteries are an emerging technology that replaces the liquid electrolyte with a solid one, which improve safety and increase energy density. Still in the development and pilot testing stages.

Solid-state batteries represent one of the most promising innovations in the energy storage field for electric vehicles. Unlike conventional lithium-ion batteries which employ a liquid electrolyte, solid-state batteries use a solid electrolyte, they offer multiple benefits in both safety and performance.

One of the main advantages is the significant improvement in security. By eliminating the flammable liquid electrolyte, reduces drastically the risk of leakage, overheating, and explosion. In addition, they allow greater energy density which translates into vehicles with longer ranges without increasing the battery's weight or volume.

These batteries also demonstrate superior performance under extreme temperature conditions and have the potential to endure a greater number of charge cycles with minimal degradation. These attributes make them ideal candidates for applications that demand high performance, including long-range electric vehicles or high-performance sports vehicles.

Nevertheless, solid state batteries still face major challenges for mass commercialization. These include high production costs, difficulties in manufacturing solid electrolytes at industrial scale, and issues related to interfacial contact[1] between the electrolyte and electrodes. At present, they are in the development and pilot testing stages. Companies such as Honda, Toyota, QuantumScape and Solid Power that are leading the research and development of this technology, are working towards its implementation in vehicles that are expected to reach the market before 2030.

Other emerging technologies

In addition to traditional lithium-ion batteries and their variants, several emerging technologies hold the potential to revolutionize energy storage for electric vehicles. Although most remain in the experimental or early development stages, some of these alternatives offer notable advantages in terms of sustainability, material availability and performance.

Sodium-ion batteries: Use sodium instead of lithium as the active material. Since sodium is more abundant and less expensive, these batteries could reduce costs and improve the sustainability of supply. Although their energy density is lower than that of lithium, they are well suited for short-range applications or urban vehicles. Companies such as CATL and Faradion are leading the development of these solutions.

1 *The electrode-electrolyte interface is the critical zone where charge transfer occurs and electrochemical reactions occur, making it essential for the operation of electrochemical devices such as batteries and fuel cells*

Cobalt-free batteries: In response to the ethical and environmental concerns associated with cobalt mining, batteries are being developed that remove this element from their composition. Some optimized lithium-nickel-manganese chemistries, as well as LFP and solid-state variants, already eliminate cobalt without significantly compromising performance.

Flow Batteries: Use liquid electrolytes stored in external tanks. They are rechargeable by replacing the electrolyte and can be easily scalable. While their primary use has been stationary, some prototypes indicate potential use in heavy-duty or public transport vehicles.

Supercapacitors: Store energy in electrostatic form, enabling extremely fast charges and discharges and a very long lifespan. Nevertheless, its low energy density limits the use as a primary source of energy. They are being explored as a complement to batteries in hybrid vehicles and regenerative braking systems.

Other lines of innovation include:

- Hybrid supercapacitors, which combine the fast charging and discharging of capacitors with the storage capacity of batteries.
- Structural batteries, integrated into the vehicle's body, which would reduce weight and increase usable space.
- Nanotechnology applied to electrodes, which improves reaction rate and storage capacity.

Although still confronted with technical, economic, and infrastructure challenges, these technologies represent a crucial line of research to diversify energy storage options and reduce reliance on critical materials in electric mobility. While promising, they need to overcome technical and cost barriers.

The table below presents relevant characteristics of the different types of technologies, regardless of their levels of development.

Table 05. Battery technologies for Electric Vehicles

Technology	Energy Density (Wh/kg)*	Life Cycles	Relative Cost	Thermal Safety	Critical Resources	Common Applications
Lithium-Ion (NMC/NCA)	150–250	2000–3000	Medium-High	Medium	Cobalt, Nickel	Mid- and high-range vehicles
Lithium Iron Phosphate ($LiFePO_4$)	90–160	>3000	Low	High	Iron, Lithium	Buses, urban vehicles, fleets
Solid-State	>300 (potential)	>5000 (estimated)	High	Very high	Lithium (no liquid)	Prototypes, high-end models
Sodium-Ion	100–160 (estimated)	1000–2000	Low	High	Sodium	Urban vehicles, second generation
Flow Batteries	30–50	Very high	Medium	High	Vanadium (or others)	Heavy transport, storage
Supercapacitors	<10	>100,000	High	Very high	Carbon or other dielectrics	Braking systems, hybrids

* Indicates how much energy a battery can store per kilogram of weight. A battery with high gravimetric energy density can store more energy without being heavy, which is important for applications such as electric vehicles and portable devices where weight is crucial.

In China, LFP dominates the market, representing 64% in 2024. By 2030, that figure is projected to reach 76%, driven by the priority of affordability in the world's largest EV market.

Outside China, NMC remains the leading technology, supported by consumer demand for longer range and premium performance.

- North America: NMC accounts for 71% of the market in 2024, with a slight decline to 69% projected by 2030.
- Europe: NMC's share is expected to increase from 69% in 2024 to 71% by 2030.
- South Korea and Japan: Both countries show similar trends, with NMC strengthening its dominance while LFP remains limited or non-existent.

Table 06. Trends of Regional Markets - 2024

Trends of Regional Markets - 2024			
Region/Country	%NMC	% LFP	% others
China	0,27	0,64	0,09
North America	0,71	0,07	0,22
Europe	0,69	0,08	0,23
South Korea	0,62	0,04	0,34
Japan	0,58	0	0,42

Fuente: Elements[2]

2 https://elements.visualcapitalist.com/charted-battery-capacity-by-country-2024-2030/

Technical and Design Aspects

Structure of a battery pack

An EV battery pack is composed of multiple levels of integration. The basic unit is the cell, which can be cylindrical, prismatic or pouch shaped. Multiple cells are grouped into modules, which are then assembled into a "pack" or complete set of batteries. The pack also includes electrical systems, sensors, structural frames and control units that guarantee safe and efficient operation.

The internal setup of these elements affects the weight, available space, thermal capacity, and ease of repair of the system. The current trend is towards more compact and modular designs, which facilitate maintenance and production scalability.

Energy density and efficiency

Energy density is a key metric that determines how much energy can be stored per unit weight (Wh/kg) or volume (Wh/L). Higher density enables longer driving ranges without significantly increasing a vehicle's size or weight. Nevertheless, this must be balanced with safety considerations, as materials with higher energy density may be more prone to thermal risks.

Efficiency also refers to a battery's capacity to charge and discharge energy with minimal losses. Most modern lithium-ion batteries have a round-trip efficiency above 90%, meaning that only a small fraction of energy is lost during cycling.

Battery Management Systems (BMS)

The Battery Management System (BMS) is an essential electronic unit that monitors in real time parameters such as voltage, current, temperature and state of charge (SOC). Its primary functions are to maximize performance, extend battery lifespan, and prevent failures or dangerous conditions such as overcharging, over-discharging, or short-circuiting.

The BMS also balances the cells, ensuring they operate uniformly and preventing premature degradation. In addition, it provides key data to the vehicle's control system, enabling intelligent energy management strategies.

Thermal Safety and Cooling

Thermal management is essential to prevent batteries overheating, which can lead to capacity loss, accelerated degradation, or even dangerous thermal events such as thermal runaway[3]. To this end, battery packs integrate passive cooling systems (through heat conduction) or active cooling systems (forced air use, liquid refrigerants or thermal plates).

In high-performance vehicles, liquid cooling solutions are preferred due to their superior capability to dissipate heat uniformly. Advanced technologies such as phase-change materials (PCMs) and intelligent thermal systems that adapt the response to the operating environment and battery health, are also being explored. Cooling systems (air, liquid, or cold plates) prevent overheating and increase battery lifespan.

Performance and Life Cycle

Range and charging times

The range of an electric vehicle (EV) refers to the distance it can travel on a single full battery charge. This parameter depends on multiple factors, including battery capacity (kWh), vehicle energy efficiency (Wh/km), driving style, air conditioning usage, terrain topography, and weather conditions.

Current EVs offer ranges from around 200 km to over 600 km, with high-end models reaching the highest ranges thanks to higher-capacity batteries and optimized aerodynamic designs. Vehicles such as the Tesla Model S or the BYD Han EV exceed 600 km, while the Tesla Lucid Air reaches over 800 km. Urban vehicles such as the Renault Zoe or the Nissan Leaf fall between the intermediate range (300 – 400 km).

Regarding charging times, there are three main levels:

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3 *Thermal runaway is a phenomenon in which the temperature of a battery cell rises uncontrollably and rapidly. This increase in temperature can lead to exothermic chemical reactions within the cell, generating more heat and potentially causing fires or explosions. It is a significant risk in lithium-ion batteries, and can be initiated by a variety of factors, including short circuits, overcharging, or physical damage.*

- **Slow Charge (Level 1)**: Uses household AC current (110-120V) and requires from 8 to 20 hours for a full charge. Ideal for residential use with low demand.
- **Semi-fast charging (Level 2)**: Uses 220-240 V alternating current, common in advanced residential installations or public stations. It requires between 4 and 8 hours.
- **Fast Charging (Level 3 or DC Fast Charging):** Uses direct current and can recharge between 20% and 80% of the battery in 20 to 40 minutes, depending on the model and available power (50-350 kW).

In addition, emerging technologies, such as ultra-fast charging (over 250 kW), and bidirectional charging are making progress, as well as the development of smart charging networks that allow charging time to be programmed according to the price and energy availability of the grid.

Recently, several companies have announced ultra-fast charging systems capable of charging an equivalent to a range of 400km in just 5 minutes.

The combination of longer ranges and shorter charging times has been key to improve the consumer acceptance of electric vehicles, significantly reducing the so-called "range anxiety".

Degradation and Factors Affecting Lifespan

Battery degradation in electric vehicles is a natural phenomenon that occurs with use and over time. As charge-discharge cycles accumulate, the battery capacity gradually declines, reducing the vehicle's range.

Among the main factors that affect lifespan are:

- **Temperature:** High temperatures accelerate chemical reactions within the battery, causing further degradation. Extremely low temperatures, on the other hand, temporarily reduce performance and may cause damage if not properly managed.
- **Number of Charge Cycles:** Each charge-discharge cycle contributes to the chemical wear of the cells. Although modern batteries withstand thousands of cycles, their performance gradually decreases, particularly with frequent full charges and deep discharges.
- **Depth of Discharge (DoD)**: Fully discharging a battery shortens its lifespan more quickly than partial discharges. For this reason, many manufacturers limit battery use to a safe range (e.g., between 10% and 90% of its capacity).
- **Charge rate**: Frequent fast charges generate more heat and can impact the internal structure of cells. Although convenient, alternating fast charges with slower charges helps preserve battery life.
- **Driving style:** Aggressive driving (hard acceleration and braking) demands more power and more intense battery cycling, which can also contribute to further degradation.

Under normal use conditions, many EV batteries maintain over 70–80% of their original capacity after 8 to 10 years. In addition, manufacturers employ technologies such as active thermal management[4] and cell balancing to maximize lifespan as much as possible.

Reuse and batteries second life

Once EV batteries have lost a significant proportion of their capacity (usually when drop below 70–80% of their original capacity), they are no longer optimal for automotive use due to reduced range. Nevertheless, rather than being discarded, these batteries can be repurposed for a second life in stationary applications.

Among the most common second-life applications of these batteries are:

- Residential and commercial energy storage: Integrated with solar or wind energy systems, they store surplus generation for use at night or during power outages.
- Grid storage: Support grid stability by storing energy at times of low demand and releasing it at peak consumption, improving the efficiency of the electricity system.
- EV charging stations: Used to store energy during off-peak hours and supply it to electric vehicles during the day, reducing stress on the grid.

Reusing batteries reduces the demand for new raw materials, decreases e-waste, and extends the economic value of the product. Nevertheless, it

4 System that regulates the temperature of the battery and other components, such as the motor and inverter, ensuring they remain within their optimal temperature range, improving their performance and lifespan.

requires inspection, reconditioning, and certification processes to ensure safety and functionality of the batteries.

Numerous pilot projects in Europe, North America and Asia are demonstrating the technical and economic viability of these applications. Companies such as Volkswagen, ENEL x, Nissan, Renault, and some startups are actively exploring or implementing second-life programs.

Environmental Impact and Recycling

Extraction of critical materials

EV battery manufacturing depends heavily on critical materials such as lithium, cobalt, nickel, and graphite. The extraction of these resources raises major challenges related to environmental sustainability, human rights, and social justice.

Lithium mining, mainly concentrated in the so-called "Lithium Triangle" (Argentina, Bolivia and Chile), requires large volumes of water for extraction through evaporation in salt flats. This practice has generated tensions with local communities, especially in arid regions where water is a scarce resource.

Cobalt, mostly mined in the Democratic Republic of the Congo, has been subject of multiple complaints, including child labor and precarious working conditions in artisanal mines. Despite efforts for traceability and ethical certification, part of the chain still lacks transparency.

Nickel, used to increase the batteries energy density, is mainly extracted in Indonesia, the Philippines and Russia. Its mining activities, if not managed with strong environmental practices can lead to deforestation, soil contamination and impacts on local communities.

In addition, natural graphite, used as an anode material, is largely produced in China, where intensive extraction has led to air quality problems and industrial waste.

In response to these challenges, global initiatives for responsible mining are being promoted, including voluntary certifications schemes, benefit-sharing agreements, and rigorous environmental impact assessments. At the industrial level, some companies are working to reduce the use of problematic materials through new chemistries, while others are investing in recycling and digital traceability of their supply chains.

Ensuring that the energy transition does not replicate patterns of environmental and social exploitation is one of the great challenges. Achieving truly sustainable electric mobility will require the responsible and fair extraction of critical materials, addressing issues such as water-intensive use and precarious working conditions.

Life cycle carbon footprint

Although electric vehicles (EVs) produce no direct emissions during their operation, their total carbon footprint must be assessed across the entire life cycle: manufacturing, use, and end-of-life management. This comprehensive perspective is essential to accurately measure their true environmental impact.

Battery manufacturing: the most intensive stage

The production of lithium-ion batteries represents 30%-50% of the total emissions associated to an EV's lifecycle. The extraction and processing of lithium, cobalt and nickel are highly energy-intensive, especially if it comes from fossil sources. For instance, manufacturing a 60 kWh battery can produce between 2 and 4 tons of CO_2 equivalent, depending on the energy mix used.

Vehicle use: advantage according to the electrical matrix

During the use phase, EVs produce no direct emissions, but their impact varies depending on the electricity source. In countries with a high share of renewable energies—such as Norway, Uruguay, Paraguay or Costa Rica—indirect emissions are minimal. On the other hand, in countries relying on coal- or diesel-based generation, such as India or South Africa, the climate benefit still exists, although it is reduced..

End of life: second life and recycling

The impact of batteries can be reduced by reusing them in stationary applications—such as storage in power grids or buildings—and through recycling, which recovers critical materials such as lithium, cobalt, or nickel. This prevents further mineral extraction and reduces the emissions associated with the production of new batteries.

Comparison with combustion vehicles

According to the International Energy Agency (IEA), considering an average distance of 150,000 km, an EV emits between 40%-60% less CO_2 equivalent over its lifetime compared to a conventional vehicle. This gap can be enhanced with the use of renewable electricity and cleaner battery technologies.

Recycling processes and circular economy

Battery recycling is a key component for the sustainability of the electric mobility ecosystem. As millions of batteries reach the end of their useful life in the coming decades, it will be crucial to implement effective collection, reuse and recycling strategies to minimize environmental impact and reduce demand for virgin raw materials.

There are three main approaches to battery recycling:

- Pyrometallurgical recycling: Consists on melting batteries at high temperatures to recover valuable metals such as cobalt, nickel and copper. This method is robust but energy-intensive and can result in the loss of certain elements such as lithium.
- Hydrometallurgical recycling: Chemical solutions are used to dissolve components and extract metals. It is more efficient than pyrometallurgy in terms of recovery and emissions, and it allows lithium to be recovered as well.
- Direct disassembly and reuse: Batteries are disassembled, and cells or modules are reused in less demanding applications, such as stationary storage, before chemical recycling.

A circular economy for batteries also involves eco-design, which involves developing batteries from the source using easily recyclable materials and structures that facilitate disassembly.

The European Union has taken the lead with the new Battery Regulation (2023), which requires manufacturers to meet minimum targets for recycled content, digital labeling, and traceability. In Latin America, countries such as Chile and Brazil are beginning to advance regulations, alongside with regional efforts to develop recycling capacities.

Automotive companies such as Tesla, Renault and CATL have developed their own recycling and material recovery programs, recognizing the strategic and economic value.

In China, Shenzhen-based GEM company is a leading recycler. It has established over 140 recycling plants across the country partnering with more than 750 vehicle and battery manufacturers and operators globally. CATL, the world's largest battery manufacturer, plans to stablish recycling operations in Europe, with the completion of its manufacturing plant in Hungary scheduled for 2026. In addition, Huayou Recycling, based in Jiaxing, Zhejiang province, east China, has formed a strategic alliance with the SUEZ Group, one of Europe's largest environmental services corporations to explore the French battery recycling market.

Moving towards a circular economy model in the battery sector not only reduces environmental impacts but also enhances supply security and creates new industrial opportunities in the energy transition.

Economic and Market Aspects

Manufacture costs and Price Trends

EV battery prices have dropped dramatically over the past decade. In 2010, the price per kWh exceeded 1,100 USD/kWh, while in 2023 it had dropped by more than 90%, reaching approximately 139 USD/kWh. According to BloombergNEF (BNEF), the average cost of battery packs declined a 20% in 2024, reaching 115 USD/kWh, the lowest level ever recorded, marking the largest annual decline since 2017.

According to the IEA[5], China currently produces over three-quarters of the batteries sold globally, and in 2024 average prices in the country fell by nearly 30%, much faster than anywhere else in the world. Batteries in China were 30% cheaper than in Europe and 20% cheaper than in North America. This decline in battery prices has made many electric vehicles (EVs) in China more affordable than their conventional counterparts.

5 *https://www.iea.org/commentaries/the-battery-industry-has-entered-a-new-phase*

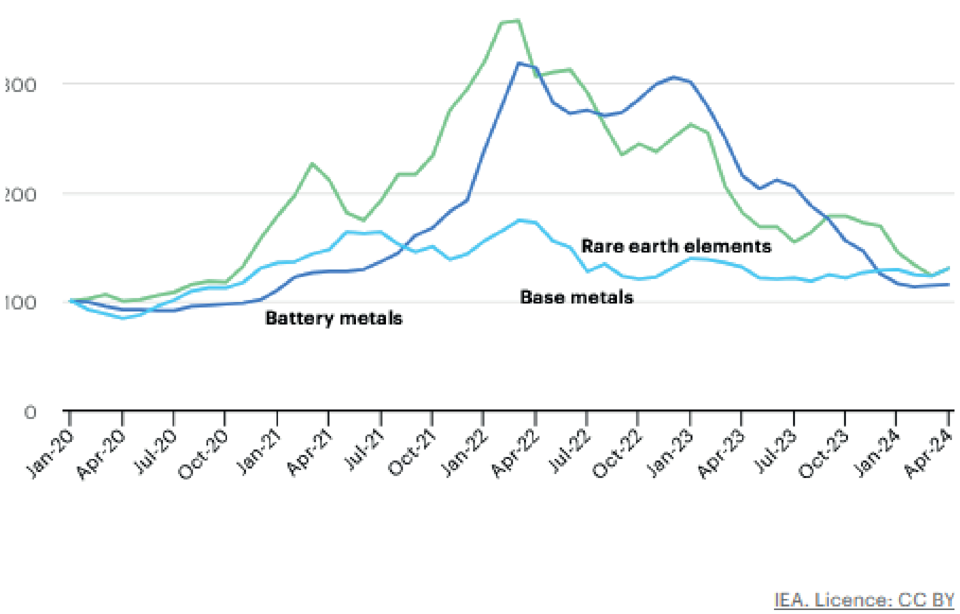
Competitiveness threshold

The International Energy Agency (IEA) reports that in 2024, the average price of a battery for an electric vehicle fell below 100 USD/kWh, a threshold widely regarded as critical for achieving cost competitiveness with conventional vehicles. This milestone represents a significant step toward cost parity with conventional vehicles..

Factors driving the reduction

- Economies of scale: Increased production, especially in China, reduces unit costs.
- Technological advances: Increased energy density and optimization of manufacturing processes.
- Reduction in commodity prices: Falling prices for lithium, cobalt and nickel have contributed about 50% of the reduction.
- The rise of lithium iron phosphate (LFP) batteries, which are cheaper and less dependent on critical materials such as cobalt and nickel, significantly influencing overall prices reductions.

Figure 17. Variation in EV battery inputs

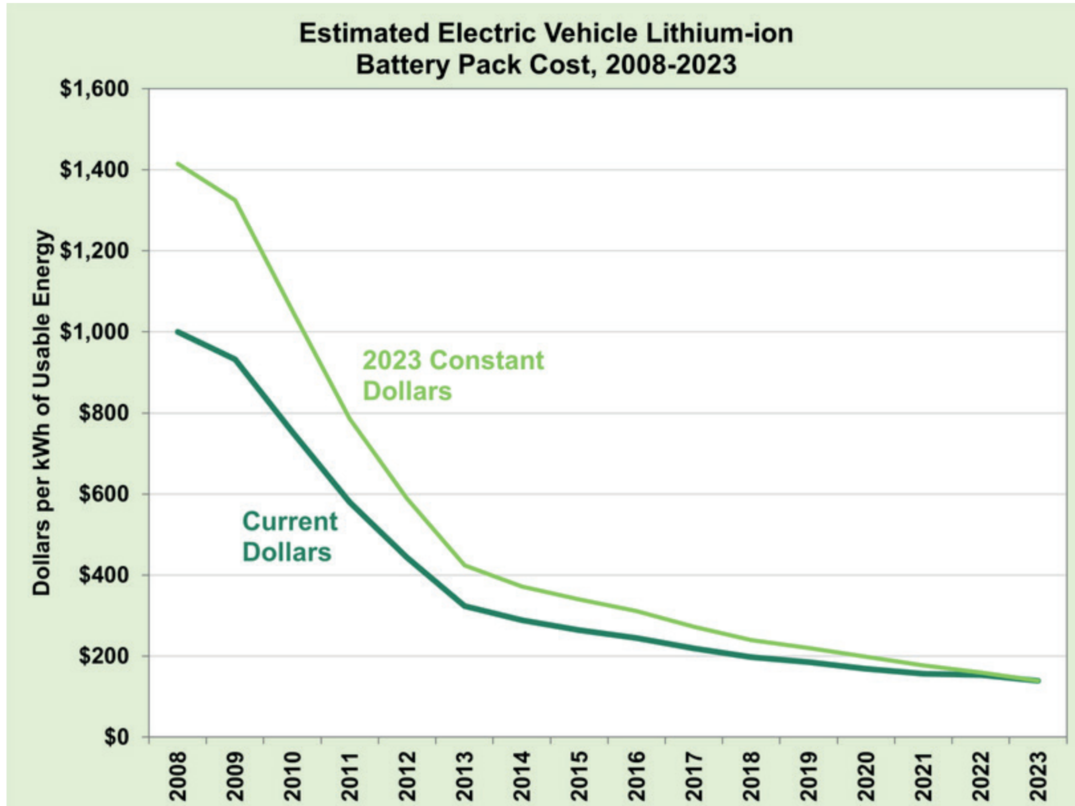


Source: IEA Global Critical Minerals Outlook 2024

Pricing by type of chemical technology

- Lithium Iron Phosphate (LFP): In 2024, only the cell cost less than 60 USD/kWh while the complete pack was around 100 USD/kWh or less.
- Lithium-ion (NMC/NCA): These are generally more expensive — averaging about 139 USD/kWh, according to DOE for 2023.

Figura 18. Variation in the price of lithium-ion batteries

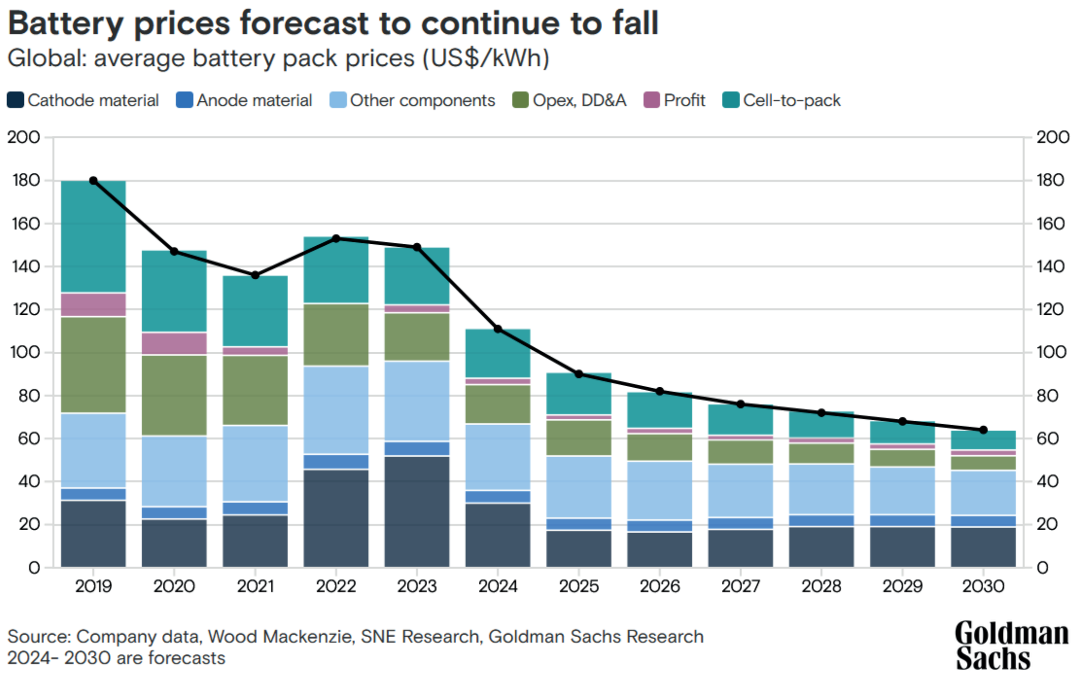


Fuente. US Department of Energy (DOE)

Future trends

- An annual decline of ~11% is anticipated until 2030
- By 2026–2030, the target is to reach 80 USD/kWh or less, driven by LFP expansion outside China and manufacturing improvements.
- Goldman Sachs projects that prices could fall to 80 USD/kWh by 2030.

Figure 19. Estimated future prices for EV batteries



Specialists in the field warn that, despite the sharp reduction in prices recorded in 2024—which has undoubtedly marked a milestone—the trend could change and become more moderate in 2025 due to the volatility in raw material costs and the adjustment in production capacity. While emerging technologies continue to advance and promise more efficient and economical batteries in the medium term, market developments will depend largely on innovation investment and the optimization of supply chains.

Cost implications

- Price reduction for EVs: Batteries represent up to 40% of the total cost of an EV; Reductions in battery prices has a direct impact on the price of vehicles.
- Parity with internal combustion vehicles: Reaching costs below the threshold of 100 USD/kWh, EVs would become competitive in the market, a factor that could accelerate their development, and even more if there are government incentives involved.

Key figures summary:

Table 06. Battery costs

Year / Projection	Approx. cost (USD/kWh)
2010	> 1 100
2023	~ 139
2024	< 100
2025	130–139
2026 (projection)	~ 80
2030 (projection)	< 80 (LFP ~36; NMC ~80)

Global Production and Supply Chains

Global Overview

China dominates the electric battery supply chain: The country produces around 75% of lithium-ion cells, accounting for 70% of cathode production capacity and 85% of anodes. Additionally controls more than half of the processing of lithium, cobalt and graphite.

South Korea and Japan also play a significant role in the middle and final stages of the process (cathode, anode and assembly production), while Europe and the US accounts for less than 10% in these components. Korean companies such as LG, SK On, and Samsung SDI strengthen manufacturing outside Korea, where they benefit from tax incentives in the U.S. In 2024, Korea contributed more than 20% of global EV battery demand, while Japan nearly 7%.

At the company level, China's CATL and BYD lead the market with a share of 37.7% and 15.4%, respectively, followed by Korea's LG Energy Solution (13%) and Samsung SDI (5.1%) and Japan's Panasonic (4.7%). Chinese companies SK On (4.8%), CALB (4.3%), Eve Energy (2.3%), Gotion (2.2%) and Sunwoda (2%) account for a smaller market share[6].

6 https://latamobility.com/byd-y-catl-lideran-mercado-de-baterias/

Manufacture capacity in the US exceeded 200 GWh in 2024 and is growing at rates nearly to 50%, thanks to incentives such as the Inflation Reduction Act[7] . The main battery manufacturers are: Panasonic (has a gigafactory in Nevada in collaboration with Tesla); LG Energy Solution (battery supplier to General Motors and other manufacturers such as Ford, Jaguar, Audi, Porsche, and Tesla), Samsung SDI (currently expanding its production capacity in North America), and Tesla (which is building new battery factories and expanding its in-house production capacity).

In Europe, companies such as CATL and LG Energy Solution currently lead the production. In addition, countries are promoting their own initiatives for the production of new generation batteries such as Basquevolt in Spain. Despite the closure of plants such as Northvolt in Sweden (Formerly Europe's largest battery manufacturer), local participation is expected to grow from 5% to 20% by 2030, partly due to foreign investment—much of it from China.

Chinese leadership and international expansion

China's leadership in battery production stems from several key factors:

- The Chinese battery ecosystem covers all stages of the supply chain, from mineral extraction and refining to the production of battery manufacturing equipment, precursors, and other components, as well as final battery and electric vehicles production.
- Years of research and development have allowed Chinese producers to perfect LFP batteries, which now account for nearly half of the global EV market and are 30% cheaper than NMC batteries.
- To remain competitive, Chinese companies have been compelled to reduce their margins in a highly competitive domestic market. Almost 100 manufacturers operate in the Chinese battery market.

China not only concentrates local production, but also extends its international influence through leading companies such as CATL and BYD, which build large facilities in Europe and the US.

CATL recently announced the opening of a new factory in Europe, adding to its existing plants already installed in Spain, Germany and Hungary, and two factories in the United States (one with Ford and another with Tesla).

BloombergNEF estimates that by 2030 China will maintain around 70% of global capacity.

Raw material sourcing

Mining of critical resources for battery manufacturing is concentrated in a small number of countries:

- **Lithium:** In 2024, Australia led production with 88,000 metric tons (37%), followed by Chile with 49,000 (20.4%), and China with 41,000 metric tons (17%). Other producers include Zimbabwe (22,000), Argentina (18,000), Brazil (10,000) and Canada (4,300). Global lithium production in 2024 reached 240,000 metric tons, with 80% allocated to battery manufacturing.
- **Cobalt:** The Democratic Republic of Congo is the largest global producer, holding more than 50% of the reserves and currently produces over 70% of current production, followed at a distance by Indonesia. The Democratic Republic of Congo's dominance is projected to decline to 57% by 2030 as Indonesia increases its production.
- **Nickel:** Indonesia is the largest producer of nickel in the world. In 2023, Indonesia produced 1.8 million metric tons, equivalent to approximately 50% of the global supply. The second largest producer is the Philippines, which reported 400 thousand metric tons in 2023, followed by Russia with 200 thousand tons and Canada with 180 thousand. A new contributor is New Caledonia, which produced 230 thousand tons in 2023, 200 thousand more than the previous year.
- **Graphite:** In 2024, China was the world's largest producer of graphite (1.27 million metric tons), representing approximately 79% of global production. Other notable producers include Brazil, Madagascar and Mozambique, although to a lesser extent. Both synthetic and natural graphite[8], are used in the anodes of lithium-ion batteries. As demand for lithium-ion batteries grows, the global demand for graphite is also projected to increase. Despite discussions about changes in the chemical composition of lithium-ion

7 The Inflation Reduction Act (IRA) of 2022 was passed by the U.S. Congress in August 2022 and signed into law by President Biden. It is currently in effect.

8 Synthetic graphite and natural graphite are two types of graphite with different characteristics and production processes. Natural graphite is found in nature and extracted from geological deposits, while synthetic graphite is produced from carbon-rich raw materials, such as petroleum coke, using high-temperature processes.

batteries, graphite is expected to remain a key raw material in electric vehicle batteries for at least the next decade.

The concentration of these essential battery components in a limited number of countries creates significant vulnerabilities and risks due to uncertainty in the supply chain in the face of political tensions, logistical challenges, or ethical implications, as is the case with the global reaction over child labor in cobalt mining in the D.R. Congo.

The expected response to this reality is based on two lines of action: **innovation**, aimed at the development of new technologies, and **diversification** in the origin of materials.

Capacity Summary (2024)

Table 07. EV Battery Production Capacity (2024)

Region	Installed Capacity of EV	% Global
China	2800	0,85
North America	200	0,06
Europe	200	0,06
South Korea *	350	-
Japan *	60	-

* Production abroad. Source: Author's elaboration [9]

Government incentives and regulations

Government incentives and regulatory policies play a key role in accelerating the adoption of electric vehicles and the development of their associated supply chains, including batteries. These measures aim to reduce initial costs, promote charging infrastructure and ensure adequate environmental and safety standards.

Subsidies and tax breaks: Many governments have implemented direct subsidies for the purchase of electric vehicles. For instance, in the United States, the Inflation Reduction Act provides tax credits of up to 7,500 USD for the purchase of new electric vehicles that meet assembly and regional content requirements. In the European Union, some countries offer green bonds or VAT reductions.

In Latin America and the Caribbean (LAC), several countries such as Colombia, Chile, Costa Rica, Mexico, and Uruguay have adopted tax and tariff incentives to encourage the use of electric vehicles.

- Colombia: Provides VAT exemption, reduced tariffs, and vehicle circulation benefits. Its Electric Mobility Law (Law No. 1964 of 2019) promotes sustainable transport.
- Chile: Grants exemptions from the green tax for EVs, and a national electromobility plan, which includes targets for public fleets.
- Costa Rica: Through Law 9518, grants exemptions from import tariffs, VAT and Marchamo for electric vehicles and their infrastructure.
- Uruguay: Import tax reductions and access to customs benefits for companies that invest in charging infrastructure, among others.
- Mexico: tax incentives for electric vehicles and charging stations in certain states; it seeks to strengthen the country's role as a production center.

Non-monetary incentives: In addition to subsidies, there are other benefits such as access to preferential lanes, free parking, toll exemptions and vehicle restrictions. These measures improve the overall value proposition for consumers..

Emissions regulations and electrification targets: The European Union has established a ban on the sale of new internal combustion vehicles starting in 2035. China, meanwhile, applies sales quotas for new energy vehicles (NEVs) for manufacturers, a similar mechanism adopted by certain states such as California

In LAC, there are no prohibitions yet on the sale of conventional vehicles, but more than 20 countries have defined national electromobility strategies, and cities such as Bogotá, Santiago and Mexico City have imple-

9 *Japón y Corea del Sur tienen la mayor parte de su producción principalmente en EE. UU., Europa y otros mercados.*

mented electric buses in public transport.

Infrastructure and production support: Many countries also allocate public funds to the installation of charging stations, the development of battery technologies, and the construction of gigafactories. Initiatives such as the *European Battery Alliance*[10] or the US plan *Battery Materials Processing Grants*[11] seek to reduce dependence on foreign countries and strengthen strategic autonomy.

In LAC, countries such as Brazil and Argentina are working to develop industrial capabilities in batteries, while several governments support public-private partnerships to accelerate the expansion of charging infrastructure.

Recycling and second-life standards: Regulatory frameworks are being developed to require manufacturers to guarantee the collection, reuse and recycling of end-of-life batteries. Europe is leading this field with the 2023 Battery Regulation, which sets targets for recycling and the use of secondary materials.

Still in the initial phase in the region. Nevertheless, there is growing interest in the integration of circular economy principles into future regulations, particularly in countries that extract lithium such as Bolivia, Chile and Argentina.

These incentives and regulations not only accelerate EV adoption but also guide the industry toward more sustainable and responsible practices in the use of critical resources, and environmental regulations drive EV adoption in countries such as Norway, China, and the United States.

Challenges and Future Prospects

Scalability and raw materials supply

The accelerated growth of electric mobility brings major challenges in terms of industrial scalability and sustainable access to critical raw materials for battery manufacturing, including lithium, cobalt, nickel and graphite.

10 https://single--market--economy-ec-europa-eu.translate.goog/industry/industrial-alliances/european-battery-alliance_en?_x_tr_sl=en&_x_tr_tl=es&_x_tr_hl=es&_x_tr_pto=tc

11 https://www.energy.gov/mesc/battery-materials-processing-grants

As global demand for electric vehicles increases, pressure on supply chains for these materials intensifies. It is estimated that by 2030, lithium will need to increase at least fourfold compared to current production, while nickel and cobalt must at least double. This situation has raised concerns about possible bottlenecks that could hinder the energy transition if not properly managed.

The main countries producing raw materials are limited: Australia, Chile, China and Argentina accounts for over 85% of global lithium; the Democratic Republic of the Congo dominates cobalt production; and Indonesia leads nickel production. Moreover, China holds a dominant position in the refining of most of these minerals. This geographic concentration increases geopolitical risks and vulnerability to logistical or commercial disruptions.

The response to this challenges rests on two fundamental lines of action: innovation aimed at the development of new technologies and diversification of material sources. On the technological front, batteries are being developed that reduce or eliminate the use of cobalt and nickel (such as LFP or sodium-ion). On the other hand, several countries are implementing strategies to ensure more resilient supply chains, incentivizing responsible mining, recycling and the exploration of new deposits.

Fostering a circular economy is also essential: extending battery life, reusing them in stationary applications, and enhancing recycling processes will contribute to reduce pressure on virgin resources. Furthermore, designing batteries for easy disassembly and material recovery will become an increasingly important practice in the coming years.

The capacity to scale battery production while maintaining environmental and social sustainability will be a key determinant for the success of the transition towards global and inclusive electric mobility.

Innovation in energy storage

In response to the need for higher energy density, lower costs, improve safety, and reduced reliance on critical materials, multiple technological innovations are being developed that could transform how electric vehicles store and use energy.

One of the most prominent lines of innovation is the development of solid-state batteries, which replace the liquid electrolyte with a solid one.

This design improves thermal safety, increased energy density, and extends life service. While their large-scale commercialization still faces technical and cost challenges, these batteries are expected to begin implemented in high-end vehicles toward the end of this decade.

Another important advance is the boost of sodium-ion batteries, which replace lithium with sodium—a more abundant and economical material. These batteries perform well in low-temperature conditions and are particularly promising for emerging markets, where cost is a key consideration.

Research is also underway on new chemistries, such as lithium-sulfur batteries, which promise significantly higher energy density than current batteries, as well as batteries without cobalt or nickel, designed to reduce environmental impacts and mitigate supply chain risks.

These innovations are still in different stages of technological maturity, but they represent crucial opportunities to diversify the storage matrix and address scalability, security and sustainability challenges of global electric mobility.

Grid and V2G integration

The increasing adoption of electric vehicles represents not only a transformation in transportation but also an opportunity to optimize the electric system through its integration with the grid. Vehicle-to-Grid (V2G) technology enables electric vehicles to not only consume energy, but also to supply it back to the grid when needed.

V2G-capable EVs can serve as distributed storage units, providing stability and flexibility to the power grid. During periods of low demand, vehicles charge their batteries, and during peak consumption or emergencies, they can feed some of that stored energy, helping to balance energy supply and demand.

This functionality is particularly valuable for grids that integrate variable renewable sources, such as solar and wind, which require backup and buffering mechanisms. In addition, it enables users to actively participate in the energy market, earning economic benefits for contributing energy to the grid.

There are three main modalities:

- V2G (Vehicle-to-Grid): bidirectional transfer between the EV and the power grid.
- V2H (Vehicle-to-Home): The vehicle supplies energy to a home.
- V2B (Vehicle-to-Building): integration with the electrical systems of buildings or commercial facilities.

Nevertheless, the implementation of V2G faces technical, regulatory, and economic challenges. It requires bidirectional charging infrastructure, interoperability standards, adequate incentives, and regulatory frameworks that acknowledge the active role of users.

Some countries such as Japan, the Netherlands and the United Kingdom have initiated successful V2G pilot projects, and manufacturers such as Nissan and Ford already offer models compatible with this technology. In the future, the mass integration of electric vehicles into the grid could become an essential component of smart and resilient energy systems.

Conclusions

Batteries for electric vehicles represent a fundamental pillar in the transition toward cleaner and more sustainable transport system. As discussed in this chapter, while current technologies have achieved remarkable levels of efficiency and competitive costs, significant challenges remain in terms of sustainability, supply security and scalability.

Lithium-ion batteries continue to dominate the market, but an increase in technological diversification is underway, driven by innovations such as solid-state batteries, cobalt-free chemistries, and the development of alternatives such as sodium-ion batteries. These innovations aim not only to improve performance, but also respond to environmental and geopolitical concerns associated with the extraction of critical materials.

Moreover, the importance of addressing the carbon footprint of batteries from a life cycle perspective has been highlighted, promoting recycling, reuse and eco-design. The circular economy is presented as a key strategy to reduce environmental impacts and ensure a more sustainable resource supply.

In the economic and regulatory sphere, government incentives, transport electrification policies, and the strengthening of regional supply chains will be decisive in consolidating a resilient and inclusive electric mobility ecosystem with less dependence on concentrated markets.

Ultimately, the global success of electric mobility will depend not only on technological advances, but also on international cooperation, strategic planning and shared commitment of governments, industry, and society to build a more sustainable and equitable energy future.

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Critical Minerals Geopolitics

Critical minerals, indispensable for the global energy transition, have acquired a strategic role as they are used in the development of key technologies such as batteries for the production of electric vehicles and energy storage. The International Energy Agency (IEA, 2025) estimates that lithium demand will grow between 40 and 51 times between 2020 and 2040, depending on the energy transition scenario. This acceleration has made lithium a central resource, not only economic, but also geopolitical.

Currently, China processes more than 60% of the lithium and approximately 80% of the cobalt that is used for the production of electric batteries globally. In addition, it controls about 90% of the rare earths market (IEA, 2024). This comparative advantage has positioned the country as a world leader in the production and export of electric vehicles, taking advantage not only of the extraction of raw material but also of processing, battery manufacturing and vehicle assembly. This has allowed it to have an accelerated expansion of its domestic market, and an increasing export rate. In 2024, it accounted for the largest share of world exports, while the European Union remained an exporter (mainly between European countries) and the United States (US) was a net importer; its imports increased by almost 40% in 2024, while exports decreased by almost 15% (IEA, 2025).

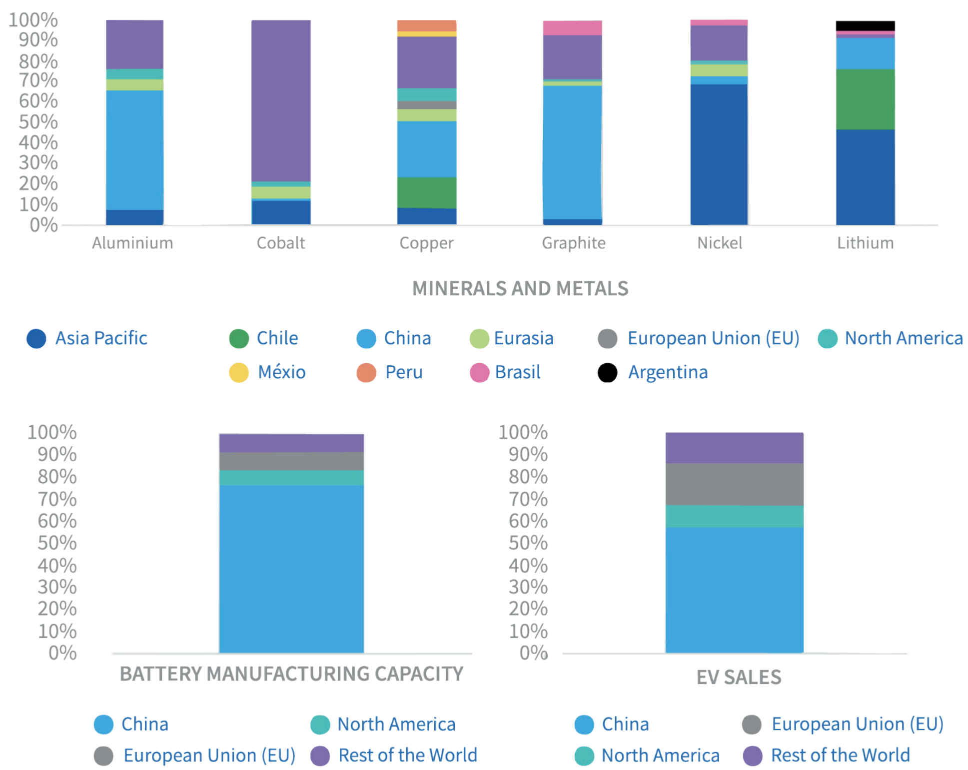
This expansion of Chinese technology has generated tensions in the geopolitics of energy. Both Europe and the United States have imposed tariff tariffs on the purchase of imported electric vehicles. The Biden Administration imposed a 100% tariff, while the European Union applied countervailing duties of up to 35.3% on electric vehicles manufactured in China, which are in addition to the 10% standard applied by the EU. These rates vary by manufacturer: Tesla has the lowest tariff at 7.8%, while BYD, Geely and SAIC brands pay around 17%, 19-20% and 35.3% respectively (Lahiri, 2025).

In addition to commercial pressures, the European Union and the United States have been outlining strategies to ensure the supply of critical minerals through strategic partnerships, investment expansion, and new regulatory frameworks that demand traceability, sustainability, and human rights in the supply chain (European Commission, 2023). The EU Fundamental Commodities Act and the US Inflation Reduction Act (IRA) reflect this urgency to diversify sources and strengthen sovereign control over these materials (Kalantzakos, 2020).

Latin America and the Caribbean in the new energy geopolitical context

While China dominates the entire electric vehicle supply and manufacturing chain, other countries - including several in the region - have a significant share of this market. In lithium, Chile (30%), Argentina (5%) and Brazil (2%); in copper, Chile (15%), Mexico (3%) and Peru (5%), and Brazil, in graphite (7%) and nickel (3%) (IDB, 2023).

Figure 20. Geographical Distribution of the Electric Vehicle Value Chain



Note. From Towards Sustainable Integration: The Potential of Electromobility in Latin America and the Caribbean, by Inter-American Development Bank (IDB), 2023. Copyright 2023 by IDB.

In this context, the EU has been promoting an active partnership policy with Latin America and the Caribbean. At the III EU-CELAC Summit in 2023, the commitment to sustainable development and fair access to strategic resources within the framework of this bi-regional cooperation was reaffirmed. One of its pillars is the promotion of strategic partnerships in critical raw materials, under the principles of sustainability, traceability, and local participation. The Global Gateway Initiative and the new EU-LAC Strategic Partnership Framework seek to promote more resilient, transparent and equitable supply chains.

The EU has also highlighted the importance of supporting Latin American countries in strengthening their institutional, regulatory and technological capacities, as well as in local industrialization and value-added development. This is framed within a shared vision of just transition, which considers the social, environmental and economic dimension of mining. Between June and July 2023, the bloc signed Memoranda of Understanding with Argentina and Chile to establish a strategic alliance in sustainable raw material value chains, including lithium.

These agreements cover five key areas for cooperation:

1. The articulation of sustainable and resilient value chains around raw materials for the development of new business models, the attraction of investments and the implementation of joint initiatives.
2. Cooperation in research and development activities along the entire production chain.
3. Coordination to promote and harmonize environmental, social and governance (ESG) criteria and regulations in line with international standards.
4. The promotion of strategic infrastructure projects.
5. Capacity building, including the training and qualification of human capital along the entire value chain. (EU-LAC Foundation, 2023).

Europe's strategy is not limited to extraction, it also places an important emphasis on extending the life cycle of lithium batteries through the reuse, remanufacturing and revaluation of batteries in stationary applications, which contributes to reducing the demand for virgin materials - and therefore their dependence on raw materials from other regions - and to closing the circle of resource use (Batteries Europe, 2021). China has opted for a strategy focused on securing the raw material because it dominates the refining of 19 of the 20 strategic minerals, accounting for about 80% of the global growth in copper and lithium supply between 2020 and 2024 (IEA, 2025).

Under this contrast between the strategic approaches of the West and China, Latin America and the Caribbean is in a strategic position, but also vulnerable. Their role in this energy transition will depend on the governance model adopted by each country.

Regional governance of critical minerals

The role that the region can play in this transition is limited by government policy orientations and reliance on traditional extractive models. Some countries, such as Bolivia and Mexico, have chosen to strengthen the role of state companies in the extraction of their minerals, while Argentina and Chile have moved towards a more liberal vision.

Tabla 08. Models of lithium industrialization in Latin America

Country	Model	State Participation	Openness to Foreign Investment	Technology and Added Value
Argentina	Full liberalization	Minimum – Provinces regulate without strong federal role	Very high, open regime with flexible conditions	Under state control; value added and technology in foreign hands
Bolivia	Total nationalization	High – the State controls the entire value chain	Limited to technical partnerships or contracts	Low local technological development; direct lithium extraction is promoted with partners
Chile	Partial nationalization	Moderate – Empresa Nacional de Litio (ENL) coordinates with Corporación Nacional de Cobre (CODELCO) / Empresa Nacional de Minería (ENAMI)	High, but with majority state control in new contracts	Focus on attracting investment with technology transfer and local value added
Mexico	Total nationalization	Very high – The state has a constitutional monopoly	Virtually zero after the 2022 reform	Production is still incipient, LitioMx seeks to develop complete chain

Source: Own elaboration based on IRR (2025) and Wilson Center (2024).

In the case of Bolivia, the Yacimientos de Litio Bolivianos Company (YLB) was created to develop industrialization under the definition of the national strategy for the exploitation and industrialization of the country's evaporitic resources through Law No. 928 of April 2017 (YLB, 2024). In November 2024, Bolivia signed an agreement with the Chinese consortium Hong Kong CBC Investment Limited, which includes battery manufacturer CATL, to build two lithium direct extraction plants for at least 1 billion dollars. Bolivia also signed a contract with Russian group Uranium One for the construction of a 970-million-dollar plant to produce 14,000 tons of lithium carbonate per year (Ramos & Solomon, 2024).

Mexico, for its part, approved in April 2022 the reform of the Mining Law that seeks to protect the country's energy sovereignty due to the growing international demand for lithium and maintain effective control over its own national security. This legislation prohibits private participation in the lithium market and declares the exploration, exploitation and use of lithium to be of public utility. In addition, it prevents concessions and private contracts for the exploitation of the mineral, which is the responsibility of the State through the decentralized public body called LitioMx (Rodríguez Garagarza, 2023; Litio para México, n.d.). It is worth mentioning that before the approval of said law, Mexico had granted concessions to Bacanora Lithium (acquired by the Chinese company Ganfeng Lithium), for the exploitation of the mineral, however, before the entry into force of the reform, the concessions were canceled.

Contrary to what the governments of Bolivia and Mexico have done, Argentina and Chile have chosen to manage the mineral differently through more open markets for its industrialization. In its National Lithium Strategy (ENL, for its acronym in Spanish), Chile seeks to reduce external dependence, increase state supervision and promote the development of activities with greater added value. While Argentina, unlike its neighbors, has completely liberalized the industrialization of lithium (Chekerdjieva, 2025).

These models of lithium governance not only show technical or economic decisions, but they are also international insertion strategies that shape the role of each country in the new geopolitics of the energy transition. In this regard, ECLAC (2023) warns of the region's lag in industrial transformation and strategic capitalization of its resources, despite having significant reserves.

Barriers and ppportunities for LAC in the lithium geopolitics

As evidenced, there is currently an absence of cooperation mechanisms between countries with higher reserves, which prevents them from negotiating as a block, having aligned regulations or defining common prices. These structural challenges limit the region's ability to capture greater added value and position itself as a relevant geopolitical actor without falling into extractive dynamics.

On the other hand, there are not enough technical capacities at the national or regional level, so it is almost completely dependent on foreign technology for the direct extraction of lithium, processing and production of battery cells, but also in the recycling and reuse of this raw material, which can be an opportunity for countries that do not have reserves of these minerals.

In Costa Rica, for example, businesses have been developing around the second life of batteries. Currently, companies such as Fortech have developed technology for proper management, reuse and recycling of lithium batteries in the country, making it the first developing country with this capacity. The company has received support from the German Cooperation Agency – GIZ to develop a pilot plan based on a public-private partnership model to support municipalities and companies that sell lithium battery products to develop synergies and create new technical capabilities.

This project also involved the academic, who carried out an analysis of the life cycle that Fortech follows in the processing of lithium batteries and confirmed that the method used is achieved with fewer emissions than extractions in mines in Africa and South America (FORTECH & GIZ, 2023). Thanks to the success of the project, Fortech and GIZ are preparing a project to implement this technology in other countries, for example, in Mexico.

This type of initiative demonstrates that all countries in the region can be strategically inserted into the value chain of critical minerals through technological innovation, international cooperation and the development of local capacities. Cases such as that of Costa Rica show that the energy transition is not only based on extraction, but also on how inclusive, circular and sustainable models are developed to generate jobs and value at the national and regional levels. In this sense, the region has the possibility of becoming just one more supplier to become the protagonist of a just transition.

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Charging Infrastructure

Electric vehicles charging infrastructure

Introduction

The transition to sustainable mobility demands not only efficient vehicles and clean and sustainable energy sources, but also adequate infrastructure that ensures viability, safety and adequate availability. Within this infrastructure, the charging network for electric vehicles (EVs) becomes a fundamental pillar, especially in Latin American and Caribbean countries, where connectivity, investment and urban planning challenges are intertwined with energy diversification opportunities.

Decisions around the design, location, capacity and technology of charging systems must be integrated with national energy policies, taking advantage of each country's comparative advantages. This section will address the electrical charging infrastructure, while the chapter corresponding to green hydrogen (H_2) will be treated separately, given the specificity of its technical and infrastructure requirements.

Definition and classification of charging infrastructure

Charging infrastructure refers to the set of physical, technological and energy elements necessary to provide charging services to these vehicles. This includes everything from connection points and transformers to intelligent energy management systems, integrating with urban and rural electricity grids.

In functional terms, it falls into two broad categories:

- **Public charging:** it is located in spaces open to the public, whether they are public property (streets, parks, national or subnational state agencies) or private (parking lots of shopping centers, supermarkets, parking lots or service centers). Your planning should consider factors such as accessibility, user turnover, and energy availability.
- **Private charging:** installed in private homes or business infrastructures with restricted access. Although its use is more predictable and its management easier, it represents a critical component in the decentralization of energy demand.

This classification not only responds to physical access criteria, but also to consumption profiles and energy planning. Therefore, its integration into strategies to promote sustainable mobility is essential to avoid unnecessary pressures on the electricity grid and promote the efficient use of energy resources and existing infrastructures.

EV charging network levels

Considering the different types of users, dwell times and energy needs, four functional levels are identified for the development of charging infrastructure:

First level: home charging. These are low power installations (generally up to 7.4 kW in alternating current) that allow users to charge their vehicles at night. In contexts where there are multi-hour rates, this modality allows to shift demand towards times of lower consumption, favoring the balance of the network and reducing costs for the user (IEA, 2024).

Second level: charging at extended dwell points. They are low to medium power charging stations, usually in alternating current (AC), located in places such as office parking lots, shopping centers, restaurants and supermarkets. User dwell time allows for longer charges without requiring high speed. The combination with smart management systems (smart charging) makes it possible to optimize energy consumption.

Third level: fast charging in direct current (DC). These points are located in strategic locations such as intercity corridors or areas of high vehicle turnover. They offer powers of between 50 and 150 kW, reducing the recharging time to less than an hour. Its implementation requires robust electrical infrastructure and grid impact assessment (Olade, 2023).

Fourth level: ultra-fast and large weight charging. Designed for heavy-duty vehicles such as electric buses and trucks, this infrastructure requires powers in excess of 150 kW, reaching up to 350 kW or more. Its implementation should consider transformer capacities, medium voltage lines and energy availability, as well as strategies to avoid demand peaks (IRENA, 2023).

Infrastructure for light vehicles and micromobility

Three-wheeled vehicles, electric motorcycles, pedal-assisted bicycles, and small cars (city cars) have proliferated, especially in urban and rural areas that are difficult to access. This type of mobility, in addition to representing an affordable and efficient solution for last mile logistics and personal transport, requires specific cargo networks.

These networks, due to their lower electrical requirements, allow for territorial expansion with more accessible investments. Its integration into public spaces (parks, intermodal stations, community centers) promotes the inclusion and diversification of sustainable mobility.

Types of connectors for electric vehicles

The standardization of connectors is a crucial aspect for the interoperability and regional expansion of electric mobility. There are different types of connectors used depending on the type of charge (AC or DC), the power required and local regulations.

Alternating current (AC) charge:

- **Type 1 (SAE J1772):** Mainly used in North America and Japan. It operates up to 7.4 kW in single-phase charging.
- **Type 2 (Mennekes):** standard in Europe and adopted by several Latin American countries. Allows single-phase and three-phase charging up to 43 kW.

Direct Current (DC) charge:

- **CHAdeMO:** developed in Japan, allows powers up to 100 kW. Although its use has decreased in some markets, it is still present in vehicles of Asian origin.
- **CCS Combo 1 and 2:** the most widespread globally. CCS1 is used in North America and CCS2 in Europe and several Latin American countries. Supports power ratings above 350 kW.
- **GB/T:** Chinese standard, with variants for AC and DC. China leads its implementation, especially in urban public networks and commercial fleets (IEA, 2024).

According to the International Energy Agency (IEA, 2024), the global trend points towards the consolidation of the CCS standard as the main connector for fast DC charging, while type 2 dominates AC charging in the European and Latin American context. In countries such as Brazil, Chile, Colombia and Mexico, public policies and regulations are promoting the adoption of these standards to ensure compatibility and facilitate the expansion of infrastructure (Olade, 2023). However, in other markets, especially in Central America, there is an increase in the supply of vehicles with Chinese standard (GBT).

This diversity in connectors presents a major challenge for the region, as it limits interoperability between countries and increases charging infrastructure development costs. In this sense, it is important to move towards an articulated process of standardization, in the first instance at the subregional level since the standards also generate trust and allow to promote the electrification of other market segments, (ABB E-mobility Inc., 2022).

This diverse technology offering can also compromise the integrity of the infrastructure. In Cosa Rica, one of the countries with the largest deployment of public and private charging points, where multiple connectors coexist, users are forced to use adapters to make use of the infrastructure. Many users, due to ignorance, make improper use of these devices, for example, disconnection when there is still an active charging process. This can cause electrical arcs that damage the connectors and can even melt the adapters and become attached to the connectors.

In addition to inappropriate use, there is an increase in the supply of low-quality adapters. This is especially concerning as the risk of unsafe, unreliable and poorly designed products can hurt the scaling of an emerging market. Therefore, it is recommended that countries promote quality standards to ensure that the supply of charging devices is adequate.

Energy considerations for infrastructure planning

The deployment of electric charging infrastructure must be integrated with national energy planning. Power availability, grid stability and complementarity with renewable sources are determining factors.

Smart charging and integration with energy storage systems (stationary batteries) can mitigate grid impacts, especially in regions where electrical infrastructure is limited. It also opens the possibility of bidirectional use of energy (V2G, vehicle-to-grid), which would allow vehicles to act as distributed storage at times of high demand or low renewable generation.

Synergies between the transport and energy sectors are essential to ensure an orderly, resilient and efficient transition. This involves strengthening institutional coordination, incentivizing appropriate regulatory frameworks, and promoting investments that align sustainability objectives with economic opportunities.

In this context, it is essential to address the regulatory barriers that condition the development of charging infrastructure, for example, those that only enable concessionary companies or electricity distributors to sell energy. This limits private operators as they cannot sell the charging service per kWh, forcing them to use indirect charging schemes that take away transparency from the market.

Global perspectives on charging networks

Ultra-fast charging (High Power Charging, HPC)

This type of charging, which is not compatible for all vehicles, consists of a system of chargers of more than 350 kW that are being installed in transport corridors to allow recharges of 80-90% in less than 10 minutes, especially in Europe, China and North America. IEA (2025).

In 2024, according to IEA (2025), ultra-fast chargers (>150 kW) grew by 68% globally.

Likewise, new technologies such as BYD (China) and ABB must be taken into account, which are exploring solutions with powers of up to 1,000 kW, aimed at special segments with an emphasis on heavy vehicles.

Smart and bi-directional charging (Smart Charging and V2G)**

Smart charging and bidirectional charging

Smart charging allows optimizing electricity demand by taking advantage of the various price signals of the electricity market, which also allows optimizing costs and powers through a remote control of the system.

V2G and V2H

Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) these technologies allow EVs to act as distributed storage * offering flexibility to grids.

According to IEA (2025), about 20% of the new residential and public charging infrastructure installed in 2024 already supports V2G protocols. While OLADE promotes the adoption of these technologies in Latin America and the Caribbean as part of its renewable energy integration and grid resilience strategy (OLADE, 2024). To do this, we must not only have technological solutions, but we must also have a robust regulatory framework that promotes these uses with a criterion of systemic efficiency.

Wireless Charging

Wireless or inductive charging that is already widespread in other technological products, such as cell phones, has a development opportunity to serve urban electric fleets (taxis, buses, application vehicles). Currently and incipiently, pilot tests are being developed in the field.

This technology is expanding in China, the United States and Germany, (IEA, 2025). In the near future, this type of technology will play an interesting role in meeting special demands.

Integration with renewable energy and storage

Charging systems are increasingly integrated with photovoltaic power generation and battery storage systems. The latter may include batteries for second use.

This trend will be key in those regions with high penetrations of solar or wind energy and helps to avoid local overloads and improve the quality of charging service without competing with other uses of the power grid. At OLADE, we promote solar charging infrastructure models in areas with low power grid density, improving or expanding the charging service to rural or isolated areas (OLADE, 2024).

Distributed charging on buildings, homes and fleets

The highest growth is in residential infrastructure and workplaces, where about 65% of the total EV charging is concentrated, according to the IEA.

It is important to have centralized energy management models for the management of urban fleet loads (logistics, taxis, public transport) as an option that maximizes the use of infrastructure without stressing the electrical system. One example of these synergies is using the chargers at bus charging bays (at night) to charge taxis and fleets during the day.

Electric routes connecting LAC

Electricity routes in Latin America and the Caribbean (LAC) are a strategic pillar to consolidate the transition towards sustainable and integrated mobility. Just as pipeline networks, gas pipelines and electrical interconnections have historically facilitated energy trade, charging infrastructure for electric vehicles must be oriented towards transnational interoperability. This implies moving towards the harmonization of connector standards and communication protocols, as well as establishing a minimum system of electronic means of payment (digital wallets, QR, bank cards) that facilitates the use of the network in any country in the region.

The implementation of regional electric corridors will enhance the transport of goods and passengers in electric motor vehicles, reduce operating costs and emissions, and stimulate cross-border mobility of people, with positive effects on tourism and local economies. To achieve this, institutional coordination that promotes minimum interoperability frameworks will be key.

This process requires technical studies to identify priority corridors, size future demand, ensure economic viability and define shared governance mechanisms.

Projections and future studies

Given the rapid pace of technological and energy dynamics, it is essential to continue developing prospective studies that address charging infrastructure deployment scenarios, their impact on electricity grids, and the integration of new energy sources.

This chapter represents a starting point for the technical-energy analysis of electrical charging infrastructure. However, for the next editions of the Mobility White Paper, the incorporation of national case studies, cost-benefit analysis, public-private financing models and successful experiences in the region are foreseen.

Electric mobility is not an isolated phenomenon, but part of a structural transformation of the energy system. Therefore, future studies should contemplate interactions with rural electrification, distributed generation, storage and energy efficiency policies.

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Charging Infrastructure for Electromobility

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Photo caption: Founders of the USACH Diploma in Electromobility (Technology, Public Policies and Business Models), Hernan Nilo Fernandez and Matías Díaz Díaz

Introduction

Electromobility has established itself as a fundamental pillar in the global energy transition, offering a sustainable alternative to traditional fossil fuel-based transport. However, the massification of electric vehicles (EVs) is intrinsically linked to the development and availability of a robust, efficient and accessible EV charging infrastructure (EVCI). This chapter will delve into the key aspects of charging infrastructure, from the different types of technologies and their international standards to the current situation and public policies implemented in Chile. The objective is to provide a comprehensive vision that serves as the basis for future strategies and business models in the region.

Charging Types

Electric vehicle charging can be classified into various modalities, each with its own characteristics, advantages and challenges. The choice of one or the other depends on factors such as the power required, the time available, the physical space and the specific application of the vehicle.

Conductive Charge

Conductive charging is the most common and widespread form of EV charging. It involves a direct physical connection between the vehicle and the power source through a cable and connectors. This modality is mainly subdivided into alternating current (AC) and direct current (DC) recharging, which will be detailed in the following section. Its main advantage is efficiency in energy transfer and technological maturity. An example of this is V2G technology, where due to the use of bidirectional chargers that allow a flow of energy from the grid to the EV and vice versa, the EV can support avoiding over-demand at peak hours, thus reducing losses in the grid, maintaining a balance in the voltage of this, improvement in active power, among others. However, it requires cable handling and connector standardization. Below are the advantages and disadvantages associated with this type of technology (Memon & Rossi, 2025).

Advantages:

- **Maturity**: Mature technology that enables an established infrastructure that has been widely adopted.
- **Costs**: Lower costs compared to other charging technologies.
- **Efficiency**: High efficiency and fast vehicle charging that translate into shorter times.

Challenges:

- **Connection**: Requires wiring for the physical connection between the EV and the charging point.
- **Wear and tear**: The use of elements for the physical connection of the elements produces wear and tear that requires maintenance and replacement of components.

The following Figure 21. presents the development over time of the conductive charging by region worldwide.

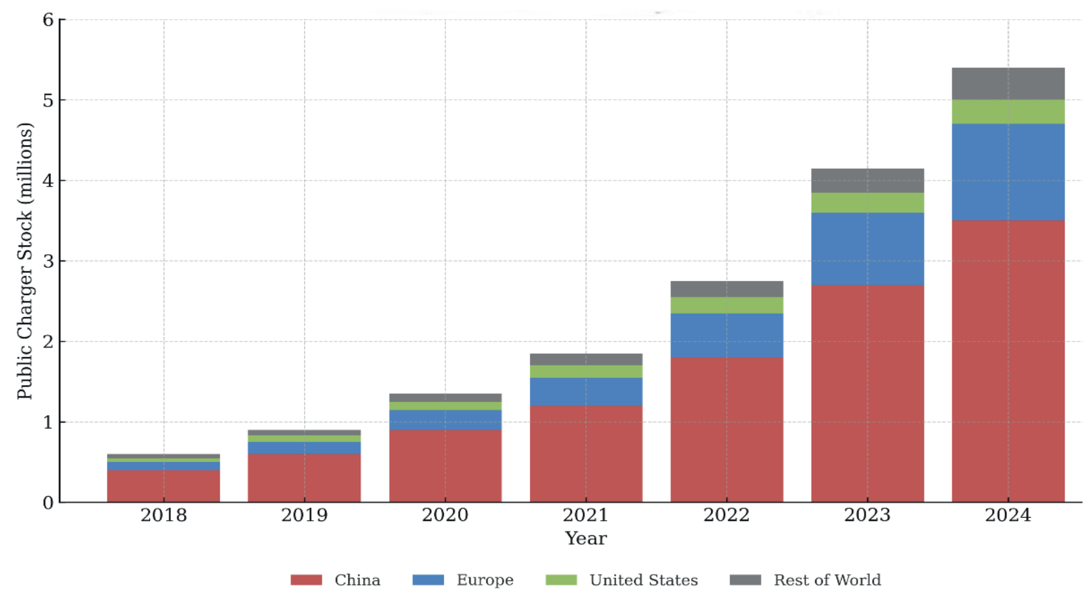


Figure 21. Worldwide Conductive Charging Development (Global EV Outlook 2025 Expanding Sales in Diverse Markets, n.d.).

Wireless Charge

Wireless charging bases its operation around the principle of propagation of electromagnetic waves. This is divided into 4 types: short-distance transfer (Inductive, Capacitive, Magnetic Resonance), long-distance transfer (Laser, Microwave, Radio Waves), by mechanical and acoustic force. Currently available for EVs are capacitive and inductive, the latter being the most used between the two since it can be used in greater distance ranges than its capacitive version (Shahed & Rashid, 2024). The principle of operation of this is based on the magnetic coupling between a coil located in the charging station and another inside the EV, which exchanges energy through a magnetic field. Below are the advantages and disadvantages associated with wireless charging (Memon & Rossi, 2025).

Advantages:

- **Convenience:** Eliminates the need for cables and connectors, making the charging process easier.
- **Aesthetics and safety:** Reduces cable clutter and the risk of tripping or damage from handling.
- **Safety:** Safer against adverse weather conditions.

Challenges:

- **Efficiency:** Generally, it has a slightly lower efficiency than conductive charging due to transmission losses.
- **Cost:** Deploying wireless infrastructure is often more expensive.
- **Standardization:** Although there are advances, global standardization is still in development.

Wireless charging can be static, where the vehicle must be stopped on the charging platform, or dynamic, where the vehicle is charged while moving on electrified lanes.

This technology has been addressed in greater depth over time, reflecting the upward trend of developing solutions that promote EV insertion. This is observed in Figure 22 which the evolution from 2017 onwards is shown, considering projections until 2026 throughout the world.

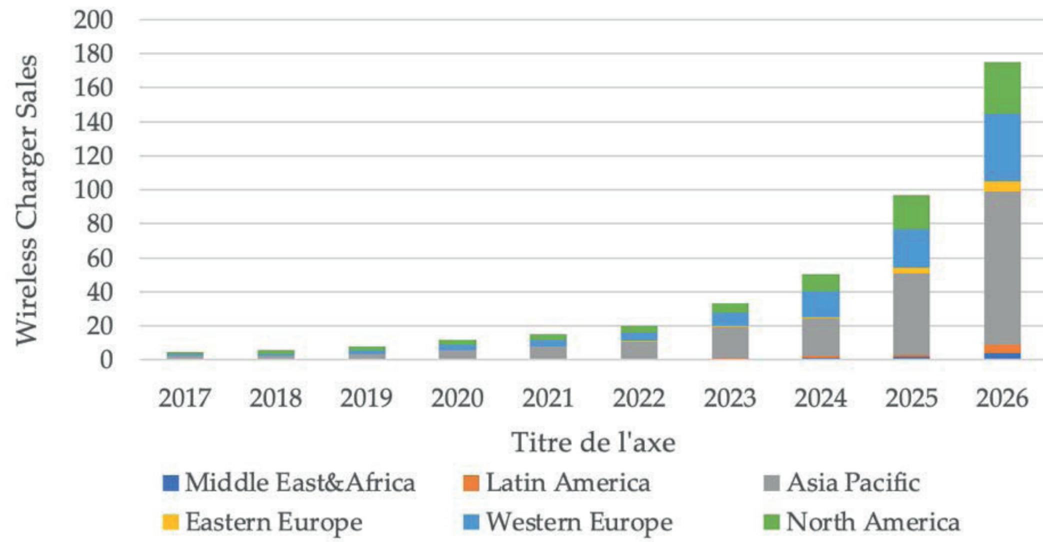


Figure 22 Development of Wireless Charges Worldwide (Mohamed et al., 2022).

As can be seen, there is a growing trend in this type of cargo, with Asia and Europe positioning themselves as the main references in the area. In contrast, Latin America still lags significantly behind in this area, thus showing the opportunity for development in that area.

Battery Swap

The Battery Swap model consists of replacing a discharged battery from the vehicle with a fully charged one at a specialized station. This process is done automatically and in a matter of minutes, similar to refueling a conventional vehicle. This alternative has advantages and disadvantages that are presented below (Mohamed et al., 2022; Shahed & Rashid, 2024):

Advantages:

- **Speed**: Eliminates the waiting times associated with charging, offering a quick solution for "charging" energy.
- **Battery optimization**: Allows operators to manage and optimize the life of batteries, charging them at times of low demand or with renewable energy sources.

- **Lower initial cost of the EV:** The cost of the battery can be separated from the purchase price of the vehicle, offering the battery as a subscription service.
- **Grid support:** In a V2G system, batteries charged on standby can deliver power to the grid in periods of maximum demand, charging in periods where energy is cheaper.

Challenges:

- **Battery standardization:** Requires rigorous standardization of battery packs between different vehicle manufacturers and models.
- **Complex Infrastructure:** Swap stations are expensive to build and maintain and require an inventory of batteries.
- **Battery ownership:** Implies a change in the ownership model of the vehicle, where the battery is not owned by the user.
- **High initial cost:** Need for a large space for the storage of batteries, which have a high cost due to the large amount required to meet the demand for EVs.
- **Higher Charging Cost:** Higher cost than charging combustion vehicles due to the monthly payment.

This model has been explored by companies such as Better Place, albeit with significant challenges in its large-scale implementation. However, it remains a viable option for vehicle fleets with predictable routes and high utilization. Below, in Figure 23 the development of battery swapping around the world is presented.

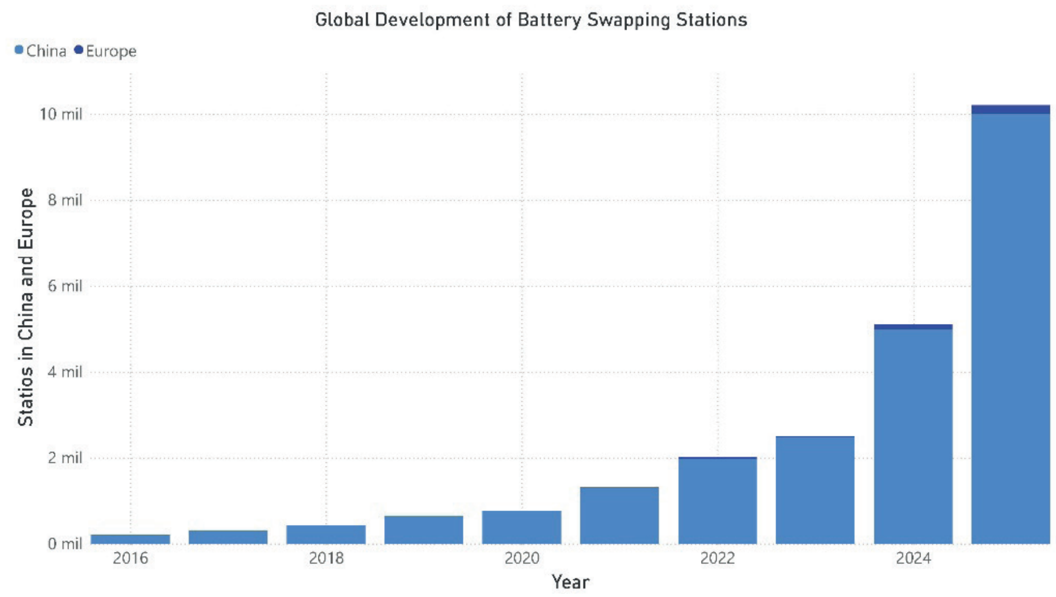


Figure 23. Global Battery Swapping Development (Wang, n.d.).

As can be seen, China is positioned as the main global player in the development of this technology, standing out for its pioneering role and its capacity for sustained expansion over time. Their leadership has served as a reference for other countries, driving the global adoption of this solution. This dynamic has begun to be replicated in other regions, such as Europe, where several countries are following a similar path towards technological transition.

As a summary, in Table 10 a comparison between the 3 charging modalities is presented, evaluating characteristics such as charging duration, charging efficiency, among others.

Table 10. Comparison between Charging Modalities (Memon & Rossi, 2025).

Characteristic	Carga Conductiva (CC)	Carga Inalámbrica (CI)	Battery Swapping (BS)
Technology Type	Cable connection	Electromagnetic waves	Battery replacement
Convenience	Moderate (requires maintenance)	High (no wires)	Very High
Efficiency	High	Moderate	Moderate
Infrastructure Cost	Moderate	High	Very high
Charging Time	Fast	Moderate to Slow	Very fast
Scalability	High	Low to moderate	Moderate
Applications	Urban areas. Parking lots. Public areas. Highways	Urban areas	Commercial fleets. High demand scenarios
Challenges	User dependency. Station availability. Wiring wear.	Loss of power. Low speed. Alignment issues.	Standardization. Battery. Management Cost

AC and DC Conductive Charging

Conductive charging is the predominant method for electric vehicles and is classified according to the type of current used: AC and DC, where each has its own characteristics and applications. In turn, these are subdivided into different loading modes according to different standards that apply worldwide, these are detailed in this section in Table 3.1, which will be addressed in depth in the next section.

Alternating Current Charging

In practice, there are several standards that establish different levels of charge for electric vehicles. In general, alternating current (AC) charging is the most used both in domestic environments and in low and medium power public stations. In this type of charging, electricity from the grid is converted to direct current (DC) by a charger onboard the vehicle, limiting the power available to the battery. As a result, charging times are often long, falling into slow or semi-fast charging categories.

Direct Current (DC) Charging

DC charging, also known as fast charging, supplies power directly to the vehicle's battery, by passing the EV's on-board charger. This allows for much higher power transfer and therefore significantly shorter recharge times.

The choice between AC and DC charging depends on the use of the vehicle and the available infrastructure. AC charging is suitable for daily recharging at home or work, while DC charging is essential for long journeys and high utilization fleets. Below, in Figure 24 the AC and DC charging diagram is presented.

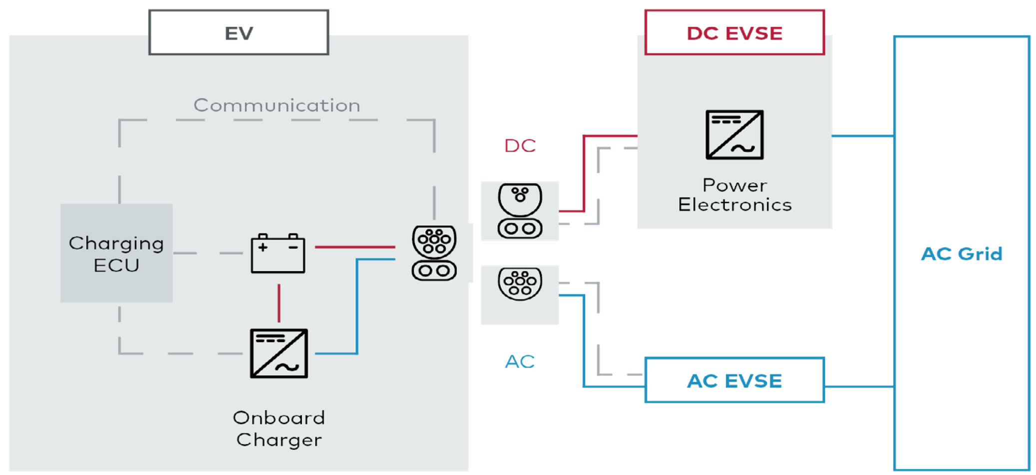


Figure 24. AC and DC Charging Configuration (Charging Interfaces | Vector, n.d.).

A comparison between the two modes is presented in Table 11 below as a summary.

Table 11: Comparison of AC and DC Conductive Charging..

Criteria	**AC Conductive Charging**	**DC Conductive Charging**
Converter location	Inside the vehicle	At the charging station
Necessary infrastructure	Simpler, residential grid can be used	Requires substations, high power, thermal management
Typical applications	Homes, offices, slow parking	Fast public stations, bus terminals, highways
Charger cost	Low to medium	High
Impact on the power grid	Low to moderate	High, can generate demand spikes

Typical applications according to type of charge

The application of a type of charge depends mainly on the level of power available, which directly influences the time needed to charge the battery. In general, shorter charging times are associated with direct current (DC) charging, while alternating current (AC) charging offers lower speeds, mainly covering slow and semi-fast charging types. Based on these characteristics, the use of AC or DC charging is defined according to the following criteria:

- **AC charging** is ideal for residential use, offices and places where the vehicle is parked for several hours.
- **DC charging** is essential for long journeys, commercial fleets and public transport, where charging time is critical.

Powers and charging times

Currently there are different power levels for EV charging, these range from single-phase with powers of 2 to 7 kW, three-phase with powers reaching 22 kW. The above is valid for AC charging, while in DC charging the power levels range from 25 kW onwards. Below, in Table 2.2 are the power levels according to the different types of AC and DC charging, along with the times required for charging in each case.

Table 2.2: AC and DC charging speeds (Ayoade & Longe, 2024).

Charge	Charging speed	Power (kW)	Time (h)
AC	Slow	1.5-2	6-10
	Semi-fast	19	1-3
DC	Fast	25-350	0.5

International Infrastructure Regulations

The standardization of EV charging infrastructure is an essential component to ensure the interoperability, safety and efficiency of the electromobility system globally. International regulations define charging modes, power levels, connector types and communication protocols, allowing vehicles from different manufacturers to use a common network of charging stations. This section presents an overview of the main international standards, their classifications and their relevance for the development of public policies and regulatory frameworks in countries in the region.

Conductive Electric Vehicle Charging System

The IEC 61851 series of standards, developed by the International Electrotechnical Commission (IEC), is the global standard for conductive charging systems. Defines charging modes, sets general specifications for charging infrastructure, communication and safety functions between the EV and the charger.

AC Charging Modes:

- **Mode 1:** Simple connection to a standard household outlet (schuko) without communication or advanced protection. Generally limited to low powers (up to 2.3 kW) and not allowed for EVs in Chile due to safety concerns. In Figure 25 you can see in detail this charging mode.

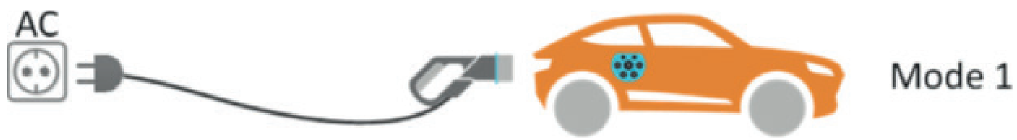


Figure 25: Charging Mode 1 (EV Charging Modes | Deltrix Chargers, n.d.).

- **Mode 2:** Use a cable with a control and protection device in the cable (IC-CPD) that incorporates safety functions and basic communication between the vehicle and the power outlet. It allows powers of up to 7.4 kW (single-phase) or 22 kW (three-phase) and connects to domestic or industrial outlets. It is ideal for occasional recharging at home or in workplaces. This charging mode is presented in Figure 26.

Figure 26: Charging Mode 2 (EV Charging Modes | Deltrix Chargers, n.d.).

- **Mode 3:** It is the most advanced and safest AC charging mode. It involves a fixed electric vehicle supply equipment (EVSE or Wallbox), which manages communication and electrical protection. It offers powers ranging from 3.7 kW to 22 kW (single-phase or three-phase) and is the standard for most dedicated public and residential charging points ((EX)UNE-EN_IEC_61851-1=2020, n.d.), which can be seen in greater detail in Figure 27.

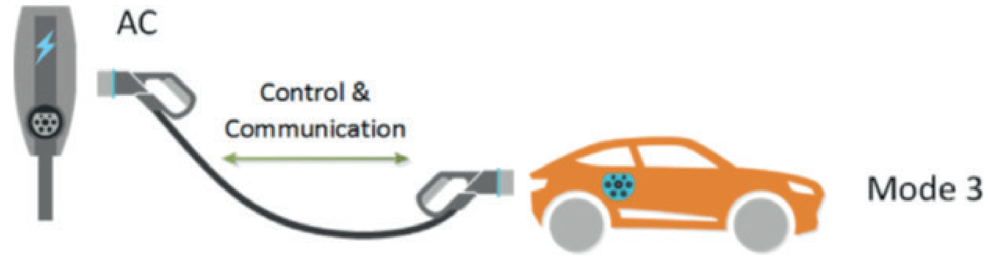


Figure 27: Charging Mode 3 (EV Charging Modes | Deltrix Chargers, n.d.).

- **Mode 4:** It is the only DC charging mode. The external EVSE performs AC/DC conversion and delivers the power directly to the vehicle battery. The powers can vary from 25 kW to more than 350 kW (ultra-fast). It is the preferred option for on-road service stations and places where recharging is required in a short time. This can be seen in Figure 28.

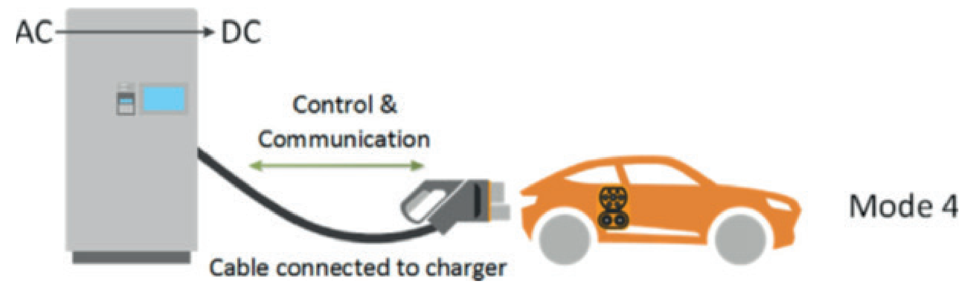


Figure 28: Charging Mode 4 (EV Charging Modes | Deltrix Chargers, n.d.).

- **IEC 62752:** Cable Control and Protection Device (IC-CPD) for Mode 2: This specific standard focuses on Mode 2 portable chargers, detailing their safety, construction and testing requirements. It is critical to ensure that these devices, which plug into home sockets, operate safely in uncontrolled environments.

SAE J1772: Electric Vehicle Connector

The classification by load levels comes mainly from the SAE J1772 standard, widely used in North America, and is based on the power supplied:

- Level 1: Slow charging (up to 2 kW) in AC, using 120 V domestic sockets. Charging time: 8–20 hours.

- Level 2: Semi-fast charging (3–22 kW) in AC, with 240 V sockets. Charging time: 4–8 hours. It is the standard in homes and public stations.

- Level 3 or DCFC (DC Fast Charging): Powers greater than 50 kW, with charging times of 20–40 minutes. Use specific connectors such as CHAdeMO, CCS or Tesla Supercharger.

Next, in Table 12 the comparison between different standards is made.

Table 12 Comparative Table of Standards (Lebrouhi et al., 2021).

Estándar	Type	Phase	Level / Mode	Voltage (V)	Current (A)
SAE J1772	AC	Single phase	Level 1	120	16
		Single phase	Level 2	240	32-80
	DC	DC	Level 1	200-450	80
		DC	Level 2	200-450	200
IEC 61851	AC, non-dedicated	Single phase	Mode 1	250	16
		Three-phase		480	16
	AC, non-dedicated	Single phase	Mode 2	250	32
		Three-phase		480	32
	AC, dedicated	Single phase	Mode 3	250	32
		Three-phase		480	32
	DC, dedicated	DC	Mode 4	400	200

Connector standards

The diversity of connectors and protocols has been a challenge for interoperability. The most relevant milestones are presented below:

AC Connectors:

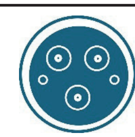
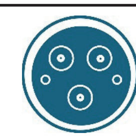
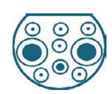
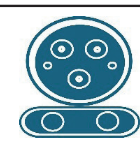
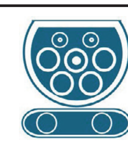
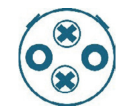
- **Type 1 (SAE J1772):** Common in North America and Japan, for single-phase charging.
- **Type 2 (Mennekes / IEC 62196):** Standard in Europe and Chile, for single-phase and three-phase charging.
- **GB/T AC:** Standard in China, similar to Type 2 but with female pins on the fixed connector.

DC Connectors:

- **CHAdeMO:** Japanese standard, common in Asian vehicles.
- **CCS Combo 1 (SAE J1772 Combo):** Combination of Type 1 connector with additional DC pins, used in North America.
- **CCS Combo 2 (Mennekes Combo / IEC 62196 Combo):** Combination of Type 2 connector with additional DC pins, standard in Europe and Chile.
- **GB/T DC:** Chinese standard for fast charging.
- **ChaoJi:** Connector in joint development between Japan and China, with the aim of supporting very high powers (up to 900 kW).

The previously presented connectors are shown in Table 3.2.

Table 3.2: Types of Connectors (Memon & Rossi, 2025).

Connector Type	China	North America	Europe	Japan
				
AC Connector	GB/T AC	SAE J1772 Type 1	IEC 62196 Type 2	SAE J1772 Type 1
				
DC connector	GB/T DC	CCS Combo 1	CCS Combo 2	CHAdeMO

Each of these connectors provides different amounts of power to the vehicle, this allows the charging time to be greater or lesser as the case may be, in Table 13 the charging time is presented along with other characteristics of the different types of connectors..

Table 13: Comparative Connector Types (Part 1) (Lebrouhi et al., 2021).

Standard	Type	Phase	Level / Mode	Connector	Charging time (h)	Location
SAE J1772	AC	Single phase	Level 1	Type 1 / Type 2	8-9	On-Board
		Single phase	Level 2	Type 2	1-3	On-Board
	DC	DC	Level 1	CHAdeMO / CCS	0.5 - 1.5	Off-Board
		DC	Level 2	CHAdeMO / CCS	0.2 – 0.58	Off-Board
IEC 62196	AC	Single-phase / three-phase	Mode 1	5.5	Type 1	On-Board
		Single-phase / three-phase	Mode 2	1	Type 2 / Mennekes	On-Board
		Three-phase	Mode 3	0.5	Type 2 / Mennekes	On-Board
	DC	-	Mode 4	0.1	CHAdeMO / CCS	Off-Board

Table 14: Comparative Connector Types (Part 2) (Lebrouhi et al., 2021).

Estándar	Tipo	Fase	Nivel / Modo	Conector	Tiempo de Carga (h)
GB/T	AC	Prohibited	Mode 1	-	-
	AC	Single phase	Mode 2	GB/T	3-5
	AC	Single-phase / three-phase	Mode 3	GB/T	1-3
	DC	-	Mode 4	GB/T - CHAdeMO	0.2-0.58

Communication protocols

The information inherent within the EV and its management is of vital importance within the electromobility ecosystem, since based on it, the conditions of the EV can be constantly monitored, such as the state of charge, the state of health of the batteries, among others. Relevant information that helps to plan the charging and discharging of the vehicle in such a way as to avoid over-demand in the network, greater energy losses, decreased charging times for users, prolonging the useful life of the batteries, etc. For this reason, different communication protocols have been developed between the EV and the charging infrastructure which are presented below:

- **OCPP (Open Charge Point Protocol):** Allows communication between charging stations and centralized management systems. Enables interoperability between the electric vehicle power supply system (SAVE, for its Spanish acronym) and the EV, exchanging information such as charging power and charging start/stop signals.

- **IEC 63119:** The IEC 63119 protocol defines the standard for communication between service providers and charging station operators in electric vehicle roaming contexts. It establishes how to exchange authentication, reservation, charging and energy use information, ensuring interoperability between different networks. It does not regulate direct communication between the vehicle and the charger, but acts at a higher level, facilitating user access to multiple operators with a single account.

- **OICP:** The Open InterCharge Protocol (OICP) is a standard developed by Hubject that enables interoperability between charging point operators (CPOs) and mobility service providers (eMSPs). It facilitates the exchange of information on availability, pricing, bookings, authentication and charging transactions, allowing EV users to access a wide network of chargers using a single platform or card. OICP is widely used in Europe and is based on secure communication via web services (SOAP).

- **IEC 61851:** Standard regulating the general aspects of conductive charging infrastructure for electric vehicles, including charging modes, power levels and safety requirements. It defines the basic communication between the charger (EVSE) and the vehicle by means of the Pilot Control (PC) signal, allowing to manage the connection, ventilation, and the maximum available current. It is the technical basis for conventional AC chargers and lays the foundation for other more advanced protocols such as ISO 15118.

- **ISO 15118:** Establishes vehicle-station communication, including functions such as Plug & Charge and bidirectional energy management (V2G). In addition, this protocol allows the automatic identification and billing of the EV (Tightiz et al., 2025).

Below, in Figure 29 is the image of the application of the different protocols mentioned above within the EV ecosystem.

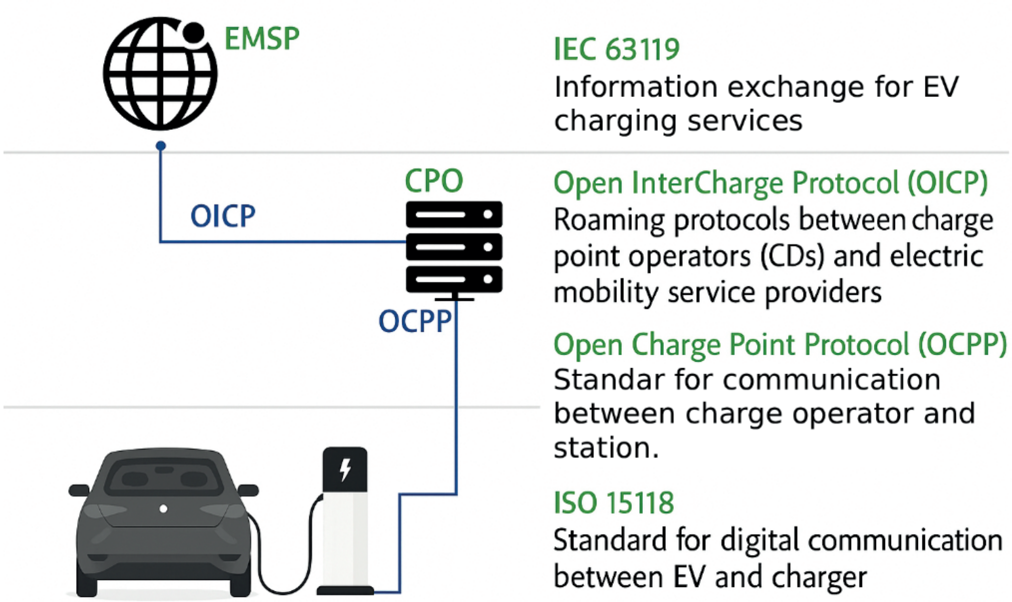


Figure 29: Schematic of EV Communication Protocols.

Harmonization and Comparison between Regions

Despite the existence of multiple standards, the industry seeks further harmonization to facilitate global interoperability. The coexistence of different types of connectors and protocols can create challenges for users and infrastructure manufacturers. Figure 3.6 shows the adoption of standards by countries.

In this regard, the adoption of standards varies by region:

- **Europe:** Leads in standardization with mandatory use of Type 2 connector and CCS. Interoperability is a priority.
- **US and Canada:** Extended use of SAE J1772 and CCS. Tesla has begun to open up its network to other manufacturers.
- **Asia:** Japan uses CHAdeMO, while China has developed its own standard (GB/T).
- **Latin America:** In the process of adoption, with a trend towards compatibility with European and North American standards.

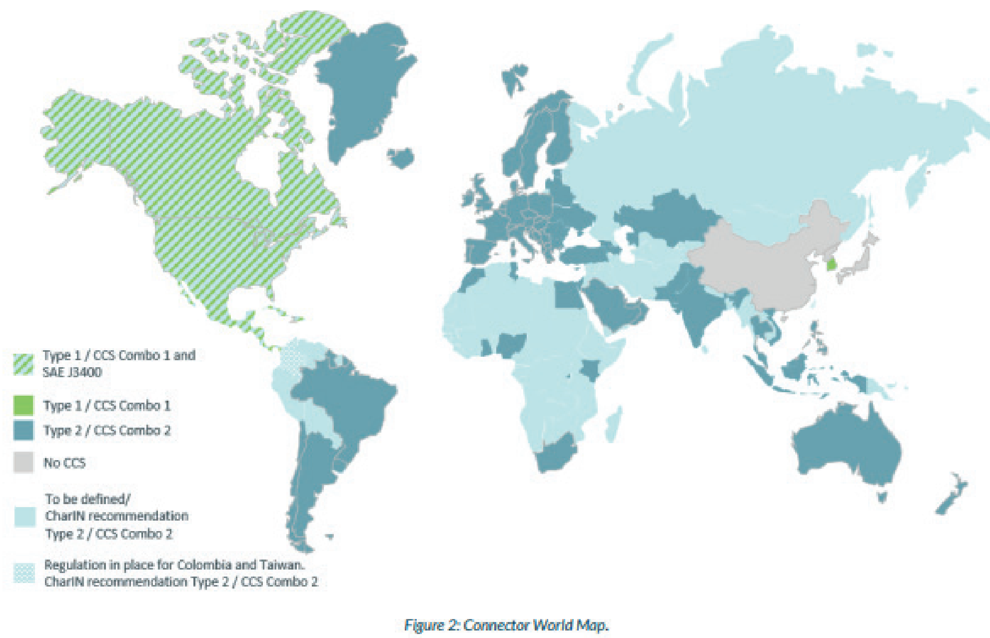


Figure 24 World map of connector standards by region (The 38th International Electric Vehicle Symposium & Exhibition - Harmonizing EV Charging Connectors: CharIN's Commitment to Global Standards, n.d.).

Preliminaries of the Chilean Case

Chile has shown a growing commitment to electromobility, setting ambitious goals and developing a regulatory framework to drive the adoption of electric vehicles and charging infrastructure.

Brief Overview of Electromobility in Chile

Electromobility in Chile has experienced significant growth in recent years, driven by public policies and growing awareness of sustainability. Although the electric vehicle fleet is still small compared to world leaders, the growth rate is remarkable.

- **Vehicle fleet growth:** Sales of electric vehicles (BEV and PHEV) have shown an upward trend, going from 197 units in 2018 to 1,769 in 2022. For the first half of 2025, 2,537 PHEV and BEV units were sold (INFORME CERO Y BAJAS EMISIONES ANAC A.G.-MAYO 2025, n.d.).

- **Market preferences:** Chilean consumers still show a preference for conventional hybrid vehicles (HEV), which are not zero emissions, but BEV and PHEV sales are increasing (INFORME CERO Y BAJAS EMISIONES ANAC A.G.-MAYO 2025, n.d.). Small, low-cost models such as the Wuling Mini BEV and BYD Dolphin have been successful in China, which could be replicated in Chile to democratize access to electromobility (Lévay et al., 2017).

- **Current infrastructure:** Chile has an operational recharging infrastructure in its twelve regions, with 396 public charging facilities, 648 private ones, 33 electro-terminals and 30 charging centers for public transport (Plataforma de Electromovilidad, n.d.). However, most public charging points are concentrated in the Metropolitan Region, which represents a barrier in other communes and regions (Plataforma de Electromovilidad, n.d.).

Description of Public Policies for EVCI

The Chilean State has implemented various policies and regulations to promote the development of EVCI.

- **National Electromobility Strategy:** First published in 2017 and updated in 2022, it sets ambitious goals for 2050, including that 100% of public transport and 40% of private vehicles be electric. It also proposes that 100% of sales of light and medium vehicles be zero emissions by 2035 (ESTRATEGIA NACIONAL DE ELECTROMOVILIDAD | Ministerio de Energía, n.d.).

- **Roadmap for the Advancement of Electromobility:** Launched in 2023, this policy establishes concrete objectives for 2026, such as the development of a master plan to promote charging infrastructure in the northern, southern and central macrozones, and the incorporation of electric buses in regions (HOJA DE RUTA PARA EL AVANCE DE LA ELECTROMOVILIDAD EN CHILE, n.d.).

- **Technical Regulatory Specification RIC No. 15:** Published in 2020 and updated in 2024, this regulation from the Superintendency of Electricity and Fuels (SEC) specifically regulates EVCI, including charging modes, connector types, and safety requirements. It is fundamental to ensure safe and standardized charging ((EX)UNE-EN_IEC_61851-1=2020, n.d.), (Global EV Outlook 2023 – Analysis - IEA, n.d.).
    - **Permitted Charging Modes:** RIC No. 15 prohibits Mode 1 for EV charging, allowing Modes 2, 3, and 4 under strict safety conditions.
    - **Protections**: Requires differential protection (Type B or Type A with DC leakage detection > 6mA) and against overcurrent, as well as monitoring the continuity of the protective conductor.
    - **Degrees of Protection:** Establishes minimum requirements for IP ratings (against ingress of solids and liquids) and IK ratings (against mechanical impacts) for EVSEs.

- **TE-6:** This document appears as complementary material to the Technical Specification RIC No.15. It emerged in 2018 in order to define the minimum functional requirements for electric vehicle power systems (undergoing modifications in the 2019-2020 period), so that they allow interoperability with external platforms, monitoring, control and traceability. Based on the above, this instrument ensures the following (MANUAL DEL USUARIO PLATAFORMA TE6 USUARIO DECLARADOR COMUNICACIÓN DE ENERGIZACIÓN DE INFRAESTRUCTURA PARA LA CARGA DE VEHÍCULOS ELÉCTRICOS, n.d.):

- **Architecture:** Defines essential blocks such as Local Control Unit, Communication Modules, Human-Machine Interfaces and Load and Security Management.
- **Interoperability:** Requires compatibility with OCPP protocol 1.6 or higher, allowing bidirectionality with centralized systems, network operators and monitoring platforms.
- **Remote Management and Traceability:** SAVE has to record and report load transactions, allow remote diagnostics, facilitate firmware updates and offer backup and restoration of critical parameters.
- **Integration with the National Charger Registry:** Establish that the SAVE must be integrated with the national information system to monitor the status of the charging infrastructure.

Success Case: Electro terminal and Public Transport Model

One of the most outstanding success stories in Chile is the electrification of public transport, particularly in Santiago, which has the second largest fleet of electric buses in the world, second only to China. This achievement is based on a public-private partnership model that has made it possible to overcome investment and operation barriers.

To carry it out, a series of measures had to be implemented that paved the way for the incorporation of electromobility in Chile within public transport. This is because, in its previous stage, public transport had a low competitiveness due to the large barriers to entry for those who wanted to be part of this ecosystem. For this reason, it was necessary to develop legal, financial and operational measures that have given the required impetus for change.

Example of these barriers correspond to the large levels of investment and market concentration, since the infrastructure required for the change was not aligned with the present one, this added to the high costs in the incorporation of new electric vehicles promoted the concentration of public transport in the entities that were already consolidated within this market. To this end, a national public transport subsidy was implemented, and the current legal framework was strengthened, giving greater powers to the Ministry of Transport and Telecommunications. Example of these measures correspond to Law No. 20,378 which creates the national subsidy for public transport (Ley Chile - Ley 20378 - Biblioteca Del Congreso Nacional, n.d.), in this way the long-term financing of the system is ensured, it also includes the creation of a panel of experts who are responsible for making the respective readjustments, thus delivering financial stability to the actors participating in the system. Other contributions correspond to Law No. 18,696, 18,059, and Supreme Decree No. 212, which gave the ministry powers to regulate public transport, such as tendering for roads in cases of congestion, environmental deterioration, or road safety risks. (Ley Chile - Decreto 212 21-NOV-1992 MINISTERIO DE TRANSPORTES Y TELECOMUNICACIONES - Biblioteca Del Congreso Nacional, n.d.; Ley Chile - Ley 18059 - Biblioteca Del Congreso Nacional, n.d.; Ley Chile - Ley 18696 - Biblioteca Del Congreso Nacional, n.d.). However, the instruments that stand out within this milestone correspond to the concession contracts for the use of roads and the specific operating conditions, which were signed with the companies that deliver the service, contracts that can be renewable giving greater flexibility to the contracting of services and guarantees of operation of the system (1er Informe de Electromovilidad 2024, n.d.).

Now, with regard to the business model implemented, this is detailed below:

- **Business Model:** To enable the electrification of public transport in Chile, especially in the Santiago GRID system, an innovative business model was implemented based on the separation of roles between fleet ownership, operation and financing. This scheme allows private companies, such as Enel X or Engie, to take charge of the acquisition of electric buses and charging infrastructure and then lease them to operators through long-term contracts. In turn, the State guarantees a fixed monthly fee to operators, which considerably reduces the financial and operational risks associated with the technological transition. This public-sector-backed leasing model has proven to be successful, as it reduces the total cost of ownership compared to diesel buses, incentivizes private investment, and accelerates the incorporation of electric buses into trunk corridors. Its implementation has progressively spread to other cities in the country, such as Rancagua, La Serena and Colina. In addition, instruments such as the possibility of extending operating contracts by incorporating electric fleets have reinforced the commitment of operators and consolidated a public policy of electromobility with a high environmental and social impact.

The initiative began with the incorporation of the first 200 electric buses, thanks to the collaboration between METBUS and BYD through Enel X and ENGIE, who led the joint implementation of buses and chargers. In parallel, the companies Vule and STP replicated the model using Yutong buses. The initial contributions of these alliances are detailed below:

- Enel X:
  - 100 BYD K9 buses operated by METBUS.
  - 100 BYD 50 kW alternating current (AC) chargers, also operated by METBUS.
- Engie:
  - 100 Yutong E12 buses operated by Vule and STP.
  - 50 Yutong 150 kW direct current (DC) chargers, operated by Vule and STP.

- **Roles of the Stakeholders:**
  - **Energy Distributors:** Invest in infrastructure and energy sales.
  - **o Bus Manufacturers (e.g. BYD):** They provide vehicles, maintenance and warranties.
  - **Public Transport Operators:** They manage routes and service, seeking efficiency and cost reduction.

- **Government:** Facilitates tenders, finances additional costs and streamlines regulatory processes and permits.

The business models implemented in public transport are presented in Figure 30 and Figure 31.

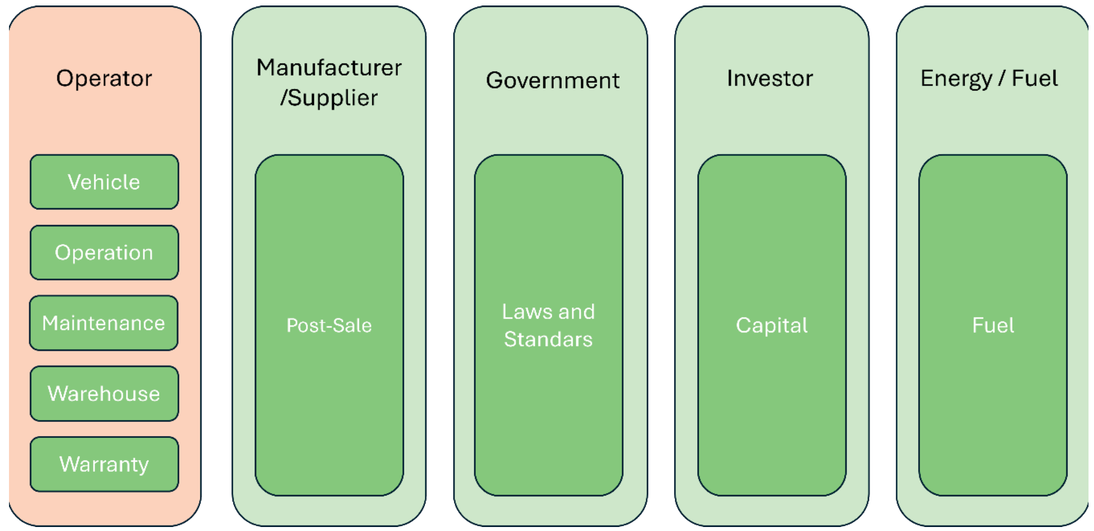


Figure 30: Pre-Electromobility Business Model in Chile.

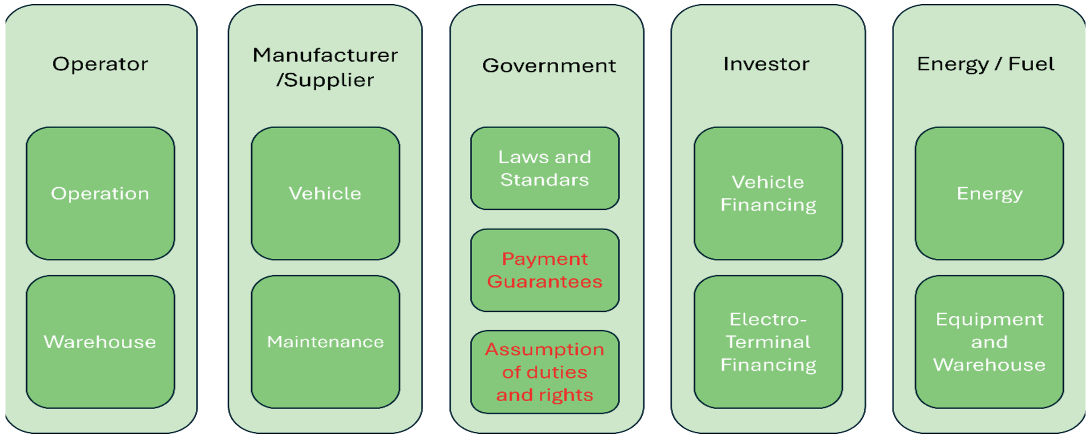


Figure 31. Electromobility Business Model in Chile.

The model described introduces significant changes with respect to what existed until recently. Previously, the operator assumed a central role, acting as owner of the vehicles, responsible for their operation, maintenance and warehouse management, in addition to providing guarantees that would allow access to electric vehicles. The rest of the actors maintained a passive participation. In contrast, the new model distributes these responsibilities among the different entities of the ecosystem. The operator focuses exclusively on the operation of the vehicles and the management of the warehouses, while the technical management and maintenance of the EVs is in the hands of the manufacturer or supplier. The State assumes the role of financial guarantor for the acquisition of vehicles, the investors are in charge of the financing of the electro-terminals, and the actors linked to energy or fuels now also participate in the provision and management of the equipment in the warehouses.

Human Capital Training for Electromobility

The success of electromobility does not depend solely on the deployment of charging infrastructure, the evolution of technical standards or the implementation of innovative business models. There is a transversal and critical component: **specialized human capital**, capable of designing, operating, maintaining and optimizing the electrical, electronic and digital systems that underpin this transformation. Without people trained in the right skills, the adoption of new technologies faces a bottleneck that slows down their massification and limits their impact.

In this sense, the **National Electromobility Strategy i**ncorporates as one of its five strategic pillars the **training of human capital,** recognizing that the projected goals for 2035 and 2050 require a significant contingent of professionals and technicians trained in multiple areas: from the engineering of electric vehicles and their recharging infrastructure, to the integration of renewable energies, energy management, cybersecurity in charging systems, and data analysis for the optimization of fleets and networks. Electromobility training must therefore respond to a growing demand for multidisciplinary knowledge, with the capacity to adapt to a constantly changing technological environment.

Diploma in Electromobility from USACH: a national and regional benchmark

The Universidad de Santiago de Chile (USACH), through the Department of Electrical Engineering (DIE) and its E2Tech center, has developed the Diploma in Electromobility, a pioneering program that integrates technical, regulatory and management knowledge, responding to the urgent need to train specialists in the area. Aimed at engineers, technicians, transport operators, authorities and professionals from the public and private sectors, this diploma course has managed to consolidate itself as a meeting point between academia, industry and the State.

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Last mile mobility as a pillar of a sustainable mobility ecosystem

Last mile mobility is understood as a proximity connection system that articulates the backbones of transport with final destinations - both for people and goods - in urban environments. This proximity mobility is key to closing the integral cycle of truly sustainable mobility.

Solving this stage with energy efficiency - maximizing the use of clean technologies and reducing energy expenditure per kilometer travelled - strengthens the central objective of achieving a sustainable transport system in the localities. In addition, it will allow decongest high-density areas or historic centers, optimize resources and reduce environmental impacts.

Strategic advantages

- Reduction of emissions and energy efficiency: the use of light vehicles with electric propulsion, electro-assisted or advanced biofuels allows to significantly reduce CO_2 emissions and local pollutants, while improving energy performance in urban logistics.
- Public-private multimodal exchange: integrating scooters, bicycles (electric or conventional) and light utility vehicles in connection with public transport trunks strengthens urban cohesion, decreases dependence on individual vehicles and boosts system efficiency.
- Traffic relief and recovery of urban spaces: smaller vehicles reduce the road footprint, free up space on the streets, promote noise reduction and improve air quality in dense areas.
- Route optimization using smart technologies: the use of artificial intelligence and planning systems optimize distances travelled, reduce energy consumption and improve logistical punctuality (SimpliRoute, 2023)

Sustainable modalities and solutions

1. Bicycles and electric charging bicycles (e-cargo bikes): ideal for fast deliveries of small volume, with zero exhaust emissions and low operating cost. In Montevideo, companies such as CargoBike and Wheele have demonstrated efficiency in urban riding, reducing CO_2 and increasing sustainable mobility. (Solutionplus, 2023a).
2. Electric scooters: agile solutions for short-distance deliveries. Its growing adoption allows a reduction in emissions and noise impact, representing an efficient alternative to internal combustion motorcycles (New Lab, 2024).
3. Light electric utility vehicles (e-tricycles, quadricycles, small vans): combine charge capacity with energy efficiency. Pilots in Quito and Montevideo have validated models with adequate autonomy and consolidated charge in urban areas (SOLUTIONSplus, 2023b).
4. Use of advanced biofuels, green hydrogen or natural gas: they complement electromobility in contexts where electrical infrastructure is limited, strengthening the energy flexibility of the urban system.

Energy and environmental impact

According to OLADE (2024a), the transport sector is the most energy intensive in LAC, representing approximately 39% of total final consumption. In this context, last-mile mobility represents a critical opportunity to decouple the growth of the sector from energy consumption and emissions, especially by adopting electric fleets and optimized routes.

A study in Uruguay revealed that the energy cost per kilometer traveled in electric vehicles can be up to 8 times lower than that of combustion vehicles (Pereira et al., 2023). This energy advantage is accompanied by improved air quality and reduced urban noise.

From an energy perspective, replacing bikes, tricycles and combustion-powered city vans with electric or electrically assisted vehicles can reduce relevant energy consumption. In addition, logistics based on optimal routes and intelligent dispatch technologies could cut up to 34% of kilometers traveled and tonnages of CO_2 emitted in urban deliveries (Sociable, 2024).

In the context of Latin America, where many cities already face high rates of urban congestion and air quality problems, such as Santiago, San Pablo or Bogotá, these electric last-mile strategies complement electromobility policies in buses and public transport, amplifying the benefits in reducing emissions and sanitary improvements (Sociable, 2024).

Social and economic sustainability

From a social point of view, these initiatives promote urban inclusion: they facilitate mobility for sectors with limited access to transport and promote local employment in new value chains (manufacturing, maintenance, driving). In projects such as La Rolita in Bogotá, gender equity has been incorporated into the operational staff of a zero-emission fleet (Reuters, 2024).

Economically, although the initial investment in electric fleets may be higher, the operating and maintenance costs are significantly lower. In the logistics sector, consolidating deliveries and using AI in planning reduces the use of vehicles and fuel, decreasing operating costs and energy cost per order delivered (Sociable, 2024).

Regional relevance

Last mile mobility, properly integrated into regional energy policies, contributes to the fulfillment of OLADE's energy efficiency objectives contemplated in its Regional Energy Efficiency Targets Technical Note (December 2024). In addition, aligning with initiatives such as WRI's Shared Mobility (2024) and ICLEI's low-carbon action plans for urban freight (LCAP-UF) (Sustainablemobility, 2021) strengthens institutional coherence and the scale of replicable solutions across the region.

In conclusion, last mile mobility represents an essential element within a regional energy and urban sustainability strategy. Its integration with clean technologies, smart planning and inclusive and economic business models supports OLADE's mission to promote energy efficiency, socio-economic development and environmental conservation. To achieve this, it is essential to generate solid data, prospective comparative studies and a regulatory approach that encourages the replication of successful models in the 27 member countries.

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Digital platforms, shared mobility and intermodality

The development of a sustainable mobility system in Latin America and the Caribbean (LAC) requires a harmonious integration between urban planning, technological innovation and the energy transition. In this context, digital transport platforms, shared mobility models and intelligent transport systems (ITS) represent key tools to move towards more efficient, inclusive and environmentally responsible urban mobility.

From an energy perspective, traditional urban mobility based on internal combustion vehicles has generated a high dependence on fossil fuels, accounting for approximately 43% of CO_2 emissions from the regional energy sector and about 40% of total final energy consumption (sieLAC – OLADE, 2024). This situation is exacerbated in densely populated urban areas, where traffic congestion not only increases energy consumption, but also contributes significantly to air and noise pollution.

Digital platforms, conceived as intelligent mobility management systems, offer concrete opportunities to transform this landscape. These tools make it possible to optimize travel planning, manage traffic in real time, integrate different modes of transport and promote energy efficiency by reducing the use of private vehicles. Universal access to mobile devices and internet networks has democratized the use of these platforms, expanding the possibilities of citizen interaction with the transport system and enhancing accessibility.

Digital platforms and transport efficiency

Digital mobility platforms, including ridesharing apps, real-time bus tracking, access to public bicycle systems, digital-metered taxi services, and carsharing, have proven to improve the operational efficiency of urban transportation. In particular, the ability to collect and analyze large volumes of data in real time makes it possible to optimize routes, reduce waiting times, minimize unnecessary travel and rationalize energy demand.

Likewise, these platforms are an essential instrument for the transition towards a low-carbon energy matrix. Some applications in the region are already starting to offer differentiated options according to the type of vehicle, allowing users to select routes with a lower carbon footprint, privileging electric or plug-in hybrid vehicles. This functionality not only empowers the user, but also contributes to environmental awareness, encouraging more sustainable mobility habits.

Shared mobility and emission reductions

Shared mobility services, such as carpooling, ridesharing and renting, play a central role in reducing dependence on private cars. By encouraging the shared use of vehicles, the need to maintain an oversized vehicle fleet is reduced, with the consequent benefits in terms of reduction of CO_2 emissions, energy consumption and demand for urban space for parking.

Empirical evidence suggests that a shared vehicle can replace between 9 and 13 private cars, depending on the urban context and use model (International Transport Forum, 2023). This change in the vehicle ownership paradigm not only has a positive impact on energy consumption, but also generates social benefits associated with equity in access to mobility, while reducing negative externalities such as pollution and road congestion.

Intermodality and energy optimization of the system

Intermodality - understood as the efficient integration of different modes of transport on the same journey - is one of the pillars of a sustainable mobility system. Digital platforms have significantly facilitated the implementation of intermodal schemes, allowing the user to plan routes that combine, for example, public transport with shared bicycles or electric vehicles for short distances.

From an energy point of view, intermodality makes it possible to use the most efficient mode of transport for each segment of the journey. Thus, long-distance journeys can be made in means of high capacity and low energy intensity (such as electric trains or mass buses), while final journeys can be completed with electric micromobility, on foot or another mode of active mobility, significantly reducing total energy consumption and associated emissions.

Intelligent Transport Systems (ITS) and Smart Cities

The incorporation of technologies such as the Internet of Things (IoT), artificial intelligence and big data analysis in urban traffic management has given way to Intelligent Transport Systems (ITS). These systems make it possible to model traffic behavior, foresee critical situations and generate automated responses in real time, making a substantial contribution to the energy efficiency of the mobility system.

In turn, ITS is a cornerstone in the development of smart cities. These cities integrate technology, sustainability and governance to improve the quality of urban life. The electrification of public transport - especially electric buses and trains - and the integration of smart charging networks are essential components of these strategies, which seek to reduce the energy intensity of the transport sector and its environmental and social impacts.

Reduced private car use and energy efficiency

For decades, the private car has been the dominant means of transportation in LAC cities. However, its extensive use has resulted in high energy consumption, high levels of pollution and inefficient occupation of urban space. Digital mobility platforms are helping to reverse this trend, offering on-demand solutions that reduce the need to own a particular vehicle.

The digitalization of mobility allows users to access transport services flexibly, only when they need them, reducing the number of vehicles in circulation and, therefore, the associated energy consumption.

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Optimization of urban space and co-benefits

The efficient management of mobility through digital platforms and shared models also has a positive impact on the configuration of urban space. The reduction of vehicles in circulation and the optimization of parking free up space for more sustainable uses, such as green areas, exclusive lanes for public transport or pedestrian and cycling infrastructure. These actions not only promote greater energy efficiency of the transport system but also improve environmental quality and encourage healthier lifestyles.

In addition, the digitalization of transport brings relevant co-benefits, such as the improvement in road safety through assistance systems, the traceability of trips and the analysis of mobility patterns that allow better planning of public policies

Future perspectives: research, innovation and strategic planning

Given the dynamism of digital technologies applied to mobility and their potential impact on the energy efficiency of the sector, it is essential to expand studies on these issues. It is recommended to promote multidisciplinary research that integrates energy, technological, social and economic aspects, with a regional perspective adapted to the specific conditions of LAC countries.

It is also crucial to strengthen energy and mobility information systems, such as sieLAC, with updated and open data that allow effective monitoring of progress towards a sustainable and resilient transport system. Evidence generation will be key for the formulation of data-based public policies, the design of appropriate incentives and the construction of social consensus around the necessary transformations.

In this sense, this chapter is a first step in documenting and analyzing the role of digital platforms in the energy transformation of transport. In future editions of the *White Paper on Sustainable Mobility*, these issues should be deepened, through the analysis of case studies, the monitoring of key indicators and the identification of replicable models in the region. Likewise, new dimensions linked to energy storage, rural electromobility, the regulation of mobility algorithms and the link with distributed renewable generation must be incorporated.

Conclusion

The transformation of urban mobility in Latin America and the Caribbean cannot be separated from the energy transition. Digital platforms, shared mobility models, intermodality and intelligent transport systems make up a technological ecosystem that makes it possible to maximize the energy efficiency of transport, reduce its environmental impact and improve equity in access to mobility.

However, these advances require comprehensive planning, updated regulatory frameworks, sustained investment in infrastructure, and a strategic vision that articulates public and private interests. The use of the region's renewable resources, combined with the potential for digitalization, make LAC a fertile territory to lead a new stage of sustainable mobility with an energy, social and environmental focus.

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Innovations in Sustainable Urban Maritime Transport and Zero Emissions Ferries: Global Lessons and Opportunities for Latin America

INSTITUTE OF THE AMERICAS

By Richard Kiy - President & CEO
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As cities in Latin America increasingly confront the intersecting challenges of climate change, urban congestion, and socio-economic inequality, the region's abundant rivers, canals, bays, and coastlines offer a unique yet underutilized opportunity: clean, efficient, and inclusive urban water transport. Historically powered by polluting diesel engines, ferries and water taxis in many parts of LATAM have lagged behind in environmental performance and modernization.

In recent years, a growing wave of innovative zero emissions ferry (ZEF) offerings are being deployed in coastal and inland riverside cities around the world deploying a range of battery-electric, hydrogen-powered, and solar-hybrid ferries.

According to a 2021 IDB report[12] dchallenges exist in the adoption of sustainable urban maritime transport solutions by LATAM cities, including the high initial capital costs of investing in zero emission ferries as well as the required shore power infrastructure. That said, several Latin American coastal cities are located in close proximity to not only reliable clean energy sources (hydro, solar, wind) but leading eco-tourism destinations and marine protected areas, so opportunities do exist to finance the development of more sustainable urban marine transport solutions in specific locales in the future.

As part the analysis presented, six urban sustainable maritime transport categories--battery-electric, hydrofoil, hydrogen-powered, solar-electric, biofuel-based, and hybrid ferry systems—are examined along with lesson learned from early adopters from around the world. Several LATAM coastal cities as well as eco-tourism destinations are also identified that, under the right circumstances, could transition their ferry and water taxi services away from the use of the lower cost heavy fuel oil (HFO) to the adoption of more sustainable urban maritime solutions in the coming years[13]. Given the ready supply of lithium in Argentina, Chile and Bolivia and the existing shipbuilding sector in Brazil, the opportunity for the development of a niche ZEF shipping building partnership is also explored learning from the early successes of Norway and New Zealand in this niche sector.

Emerging Global Trends:

With the International Maritime Organization (IMO)'s adoption of low sulfur fuel standards in 2020 and its recent adoption of Net Zero Framework (NZF), across the globe the maritime transport sector is undergoing a profound transformation. While ferries carrying people and vehicles only emit about 6% of global shipping emissions -less than 0.2% of total greenhouse gas emissions—[14] and the IMO also provides NZF exemptions for vessels operating within a country's territorial waters, there is, nevertheless, a growing movement of cities and regions worldwide towards adopting cleaner, more efficient, and climate-resilient maritime mobility solutions. Passenger ferries, a vital link for coastal and inland communities, are increasingly at the forefront of this shift.

Driven by advances in propulsion technologies, energy storage, and vessel design—as well as tightening emissions regulations and growing public demand for sustainable travel—operators are piloting and deploying a diverse range of low- and zero-emission ferry systems.

Among the most promising innovations are battery-electric ferries, which offer quiet, emissions-free operations over short to medium routes; hydrofoil vessels, which reduce drag and energy consumption by lifting above the water; hydrogen-powered ferries, capable of longer ranges while producing only water vapor as emissions; solar-electric craft, which harness

12 *Opportunities for Electric Ferries in Latin America, Inter-American Development Bank, February 2021 https://publications.iadb.org/en/opportunities-electric-ferries-latin-america*

13 *On April 11, 2025 the International Maritime Organization (IMO) approved net zero regulations to reduce greenhouse gas emissions for global shipping including the adoption of new low emission fuel standards but these standards only apply to vessels of 5,000 gross tons and above along with exemptions for domestic only traders. Also, countries are permitted to make exceptions for vessels operating under their own flag and which are only active in their territorial waters when this deemed "reasonable and practical."*

14 *https://www.washingtonpost.com/climate-solutions/2025/04/15/electric-flying-ferry-candela-p-12/*

renewable energy directly from the sun; biofuel-based ferries, allowing existing fleets to reduce carbon intensity without major vessel redesign; and hybrid systems that combine multiple energy sources for optimal flexibility and efficiency.

Early adopter countries deploying sustainable urban maritime solutions include the Scandinavian nations of Norway, Sweden and Denmark; Australia; Canada; India; Singapore; and the states of California, Maine, New York, Texas and Washington State in the United States. These solutions are not only reshaping maritime transport technology but also generating valuable lessons in infrastructure planning, energy integration, and policy support. Global case studies—from Scandinavia's pioneering electric routes to Asia's advanced hydrofoil deployments—offer insights into financing models, port electrification strategies, safety protocols, and public acceptance. Understanding these innovations and the conditions that enable their success is essential for LATAM policymakers, operators, and coastal communities that seek to scale sustainable ferry systems and accelerate the decarbonization of their respective urban maritime transport offerings.

Battery-Electric and Dual Power Hybrid Ferries: A Foundation for Decarbonized Urban Mobility

Electrification is rapidly becoming the cornerstone of maritime decarbonization. Electric and dual power hybrid ferries not only reduce air and noise pollution but also offer long-term operational cost savings—crucial for budget-constrained municipalities in the Global South.

Batería eléctrica

Among the early adopters deploying an electric ferry solution is the Argentinean ferry operator, BuqueBus, that in May 2025 launched China Zorrilla, the world's largest battery-electric ferry, operating between Buenos Aires, Argentina, and Colonia del Sacramento, Uruguay with a carrying capacity of 2,100 passengers and 226 vehicles with service across the River Plate.[15] Developed by the Australian company InCat Tasmania, the China Zorrilla, is a 130 meter long aluminum hulled catamaran powered by a 40 MWh battery system—four times larger than any previous maritime installation. Its eight electric waterjets are recharged via high-capacity DC fast-charging stations in both ports. This first of its kind, bi-national project between Argentina and Uruguay demonstrates how cross-border electrified transport can help decarbonize a high-traffic route while boosting tourism and regional integration. The China Zorrilla also offers a replicable model for similar intercity ferry corridors in Latin America, including Cartagena–Islas del Rosario or Valparaíso–Viña del Mar.

Another innovator in battery electric ferries, is the MF Ampere, the first all-electric roll-on/roll-off car ferry deployed in 2015 and operated by Norwegian based NORLED with energy supply from Norway's hydropower-backed electricity grid. The MF Ampere has 34 daily departures on weekdays with a capacity of 120 cars and 350 passengers on board. What makes the MV Ampere relevant for potential LATAM deployments is its lower fuel and maintenance costs given that this vessel is saving 1 million liters of diesel and cutting 570 tons of CO_2 annually.

On a smaller scale, Flagship Cruises & Events, a San Diego, California-based yacht charter company, is now working to launch two fully electric zero emission ferries by Fall 2026 with a carrying capacity of 245 passengers[16] and regular service between downtown San Diego and Coronado.[17] LThe ferries now being designed by Aurora Marine Design will carry will replace current diesel powered ferries and will help support the Port of San Diego's Maritime Clean Air Strategy[18].

Hybrid Ferries

Among dual power electric ferries, there are several ferries now in operation. The first hybrid diesel power-electric passenger ferry was the Hornblower Hybrid operating in San Francisco Bay by Alcatraz City Cruises since 2008[19].

More recently, the Texas Department of Transportation launched the Esperanza "Hope" Andrade ferry in 2024 along a 2.7-mile route connecting

15 *History Made on The River Dewent: INCAT Launches the World's Largest Battery-Electric Ship, INCAT news release, May 2, 2025 https://incat.com.au/history-made-on-the-derwent-river/*

16 https://www.flagshipsd.com/eferry
17 https://www.flagshipsd.com/blog/zero-emission-ferries-coming-san-diego-bay-coronado
18 https://www.offshore-energy.biz/all-electric-zero-emission-ferry-duo-to-debut-on-san-diego-coronado-route-by-2026/
19 https://www.nps.gov/articles/000/alcatraz-hybrid-ferries.htm

Galveston Island, Texas with the Bolivar Peninsula with Siemens Electric's electric propulsion system[20]. Later this year, Casco Bay Lines has plans to operate an electric-diesel hybrid ferry throughout Casco Bay from Portland, Maine running off lithium-ion batteries[21]. Additionally, Washington State Ferries, operating in the Puget Sound, has committed to re-building and modernizing its fleet of conventional diesel power ferries to hybrid-electric power by 2040 in addition to purchasing 16 new hybrid electric ferries within that timeframe[22]. Already, the first of its ferries, the Wenatchee, completed its hybrid electric power conversion in July 2025[23] and three new hybrid electric 160-auto ferries were also commissioned the same month.

Alternative Fuel hybrid ferries:

Apart from current dual power hybrid ferries operating with conventional diesel, in 2024 the French ferry operator, Brittiny Ferries, introduced two LNG-electric hybrid ferries powered by an advanced hybrid propulsion system, the Saint-Malo and the Guillaume de Normande, for service across the English Channel. The 194.7meter long Saint-Malo, which began service in January 2025, features the "biggest marine battery in the world". Designed to run on LNG, battery power or a combination of the two, the Saint-Malo operates on zero emission battery power while entering and existing ports[24].

Progress is also being made to launch the Stena Futura, a methanol-electric hybrid ferry by Swedish ferry company, Stena Lines, for its Belfast to Haysham route across the Irish Sea in September 2025. Once operational, Stena Futura and its sister ship, Stena Connecta (to begin service in 2026), will enhance the company's freight capacity by 40% on the Belfast-Heysham route in response to an increase in customer demand for services between Northern Ireland and England[25]. In addition to its methanol-ready ferries, Stena Lines is developing a new state of the art, wind powered hybrid Ro-Ro ferry, the Stena Futuro, that will be intended for transporting semi-trailers and cars and will be equipped with a hybrid propulsion system that can run on several different fuels and has the potential to reduce energy usage by 20%[26].

Electric Hydrofoil Ferries & Water Taxis: Reducing Drag and Operating Costs

Among the solutions with growing interest in selected urban centers across Europe, North America and Asia for water taxi services are electric hydrofoil ferries.

Among the leading manufacturers of e-hydrofoil ferries is the Swedish e-ferry manufacturer, Candela. The company's P-12, is a world's first electric commuter vessel that seats up to 30 passengers with speeds of up to 25 knots mph and a range of 40 nautical miles. A unique feature of the P-12 is its active foil design slashing energy use by eliminating wake and drag. To date, Candela's P-12 has entered into service in Stockholm in late 2024[27]. A forthcoming deployment is planned Fly Tahoe that plans to offer a 30-minute cross-lake service for Lake Tahoe[28], the ski and mountain resort area along the California/Nevada border with an expected start of service by 2026 pending regulatory approvals[29].

The P-12 have also been sold to customers in Saudi Arabia, New Zealand and Berlin. Plans are also underway for future deployments for other congested waterfront cities such as New York City, San Francisco and Mumbai.

CWith a carrying capacity of 150 passengers, the Northern Ireland-based firm, Artemis Technologies, is now working the deployment of its Artemis EF-24 Passenger Ferry in Belfast, Northern Ireland in October 2025 along

20 https://www.workboat.com/shift-to-hybrid-propulsion-gains-momentum-in-the-us-ferry-sector#:~:text=En%20board%20the%20Esperanza%20"Hope"%20Andrade%2C%20the%20technology%20supplied,Senesco%20Marine%20photo.
21 https://www.workboat.com/casco-bay-lines-hybrid-ferry-fleet-update-1683223461776
22 https://wsdot.wa.gov/construction-planning/major-projects/ferry-system-electrification
23 https://washingtonstatestandard.com/2025/07/10/washingtons-first-battery-ferry-to-enter-service-next-week/
24 https://www.offshore-energy.biz/brittany-ferries-brand-new-hybrid-ferry-hoists-french-flag/#:~:text=The%20hybrid%20ferry's%20christening%20ceremony,while%20entering%20and%20exiting%20ports.
25 https://news.cision.com/stena-line/r/stena-futura-successfully-completes-sea-trials-in-china,c4168069

26 https://www.offshore-energy.biz/a-sneak-peek-at-tomorrows-vessels-stena-line-presents-wind-powered-hybrid-roro-concept/
27 https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/stockholm-expands-electric-hydrofoil-ferry-service-after-successful-pilot-2025-05-06_en
28 https://candela.com/newsroom/the-first-flying-electric-ferry-in-the-us-is-coming-to-lake-tahoe/
29 https://www.tahoedailytribune.com/news/flytahoe-and-candela-showcase-technology-used-in-upcoming-electric-flying-ferry/

with plans to establish a new UK Green Shipping Corridor between Newlyn in Cornwall and St. Mary's in the Scilly Isles, a 39-mile crossing. The EF-24 has also already been pilot tested in in waters of Washington State with the goal providing expanded e-ferry hydrofoil ferry offerings to the Puget Sound and potential future cross-border services to British Columbia.[30]

A smaller, e-hydrofoil water taxi has also been developed by French company, Sea Bubbles with an initial deployment in France's Lake Annecy. Designed for 5 passengers and travel speeds of up to 12 knots (22 km/hour).[31]

Taken together, these e-hydrofoil deployments point to near-term networks where 5- to 150-passenger hydrofoils knit together lakes and harbors—Lake Tahoe in 2026, Belfast services ramping in 2024–2026, and additional U.S./Asian pilots emerging—bringing faster, low-impact urban mobility to the water. The quite operation of e-hydrofoils coupled with their low wake, make these vessels highly suitable for commuting and touristic across congested or ecologically sensitive inland waterways. In Latin America, this could benefit fast-growing suburbs and island communities like Taboga Island (off the coast of Panama City) or Isla Grande (off the coat of Cartagena, Colombia) where conventional roads and bridges are limited.

Hydrogen (H2)-Powered Ferries: Clean Energy for Longer Routes

H2 fuel-cell ferries extend zero-emission service where the batteries other all electric ferries can struggle, in particular, for longer, faster routes and where megawatt-scale charging is impractical. Already, the first commercial H2 fuel-cell power ferry, Sea Change, was developed by Switch Maritime and deployed in San Francisco Bay as part of a 6 month pilot made possible by a grant from the California Air Resources Board.[32] The service has now ended for the 70 foot and 75 passenger catamaran ferry up plans are now underway for the re-deployment of Sea Change[33]. Compared with battery hydrofoils that typically recharge after about two hours of service, Sea Change H2 fuel cell ferry has its potential to keep on schedule for longer corridors and higher speeds.

While H2-power ferry solutions are still nascent, over time Latin America could evolve to be an ideal location for future deployment. In Chile, after all, the green-hydrogen hub under development in Magallanes[34] has the potential to offer H2-powered ferry touristic services to fjord and Patagonia routes (e.g., Punta Arenas–Porvenir, Puerto Natales links) where distances, weather, and limited grid capacity favor hydrogen bunkering over high-power chargers. Also, in northeast Brazil plans are underway to develop a 3GW green hydrogen and ammonia hub that will be part of the Brazil Northeast Green Energy Park and Green Shipping Corridors Initiative.[35]

Additionally, Uruguay, already rich in wind power and advancing its own national H_2 strategy—could in the future deploy hydrogen fuel-cell ferries on the Río de la Plata between Montevideo-Colonia Sacramento and Buenos Aires. In short, in the future hydrogen ferries offer the potential to offer clean energy ferry services on medium-to-long routes in Latin America, especially in those regions now actively developing their own regional hydrogen value chains..

Solar and Electric Hybrid Ferries: Empowering Resource-Constrained Cities

For many smaller cities and rural communities across Latin America, solar-electric ferries offer a cost-effective, decentralized solution where grid connectivity is poor or unreliable. Developed by the Indian eco-marine tech company, Navalt, a100-passenger solar ferry has already been deployed for India's Kochi Water Metro powered by fast-charging lithium titanate oxide batteries.

In Argentina plans are also underway to offer solar powered ferry service in the Paraná Delta via a new EcoLauncha initiative, spearheaded by Lineas Delta Argentino S.R.L. (LDA), the region's second largest ferry operator.[36]

30 https://www.spokesman.com/stories/2025/may/08/flying-passenger-ferry-sails-puget-sound/?utm_source=chatgpt.com
31 https://www.lepoint.fr/science/seabubbles-les-bateaux-volants-entrent-en-service-sur-le-lac-d-annecy-05-07-2023-2527536_25.php#11
32 https://sanfranciscobayferry.com/sea-change-hydrogen-powered-ferry-schedule/
33 https://www.sciencedirect.com/science/article/abs/pii/S0360319925000448
34 https://h2v.eu/hydrogen-valleys/green-hydrogen-magallanes
35 https://www.accessnewswire.com/newsroom/en/oil-gas-and-energy/partnership-between-vale-and-green-energy-park-in-brazil-receives-global-gateway-1000041
36 https://www.rivieramm.com/news-content-hub/news-content-hub/biofuel-trial-plan

ACurrently in a pilot phase, the company's Delta Eco One, prototype, is currently conducting test runs in the Paraná River and Rio de La Plata with a 22-passengerr vessel operating off a 1,100 Watt solar panel on its roof that powers the onboard equipment and air conditioning.[37] Over time, it is LDA's intent to replace their 154 fleet of ferries with Ecolanchas.

Beyond Argentina, in cities like Belém (Brazil), Iquitos (Peru), or Leticia (Colombia), where river transport is dominant and solar potential is high, could benefit enormously from adopting solar-electric ferries for public or school transport

Biofuels and Renewable Diesel: Transitional Solutions for Existing Fleets

Not all ferry systems can switch to electric or hydrogen immediately. Here, biofuel and renewable diesel ferries are emerging as a practical, lower-emission alternative for maritime operators seeking to decarbonize without the immediate need for costly all-electric or hydrogen infrastructure. [38]

In New York City, several operators, including the New York City Ferry system, have begun transitioning portions of their fleets to run on renewable diesel (RD)—a drop-in fuel made from waste oils, fats, and other renewable feedstocks. This shift delivers significant reductions in lifecycle greenhouse gas emissions—often by 50–80%—while maintaining vessel performance and requiring no major engine modifications. The adoption in New York City is supported by state and municipal clean transportation incentives, aligning with New York's broader climate action goals.

Along coast of Southern California, the Catalina Express—a high-speed passenger ferry service linking Los Angeles and Catalina Island—is preparing to transition portions of its fleet to renewable diesel. This move follows successful RD deployments in other California marine fleets and leverages the state's Low Carbon Fuel Standard (LCFS) credits to offset costs. The new ferry forms part of the Port of Los Angeles' marine emissions reduction project dubbed LA MER[39]. Renewable diesel offers the Catalina Ferry an immediate pathway to slash particulate matter, NOx, and CO_2 emissions while preserving schedule reliability critical to island tourism.

These developments illustrate the growing role of biofuels and renewable diesel as near-term maritime decarbonization solutions, bridging the gap toward zero-emission technologies.

Across Latin America, coastal cities with active ferry fleets—such as Montevideo, Recife and Acapulco—could adopt biofuel-blending strategies as a bridge solution while planning for electric transitions. Also, in the case of Brazil, it could leverage its current biofuel supply chain to offer biofuel powered ferries in the future. In fact, already trials are underway for biofuel powered tug boats in Port Acu near Rio de Janeiro[40].

Conclusion

Across the globe, urban ferry systems are being reimagined as catalysts for low-carbon mobility, economic inclusion, and climate resilience. For Latin America, this transition is not only possible—it is uniquely well-suited to the region's natural endowments, demographic trends (including increased urbanization in coastal communities and tourism), and technological potential. With abundant rivers, lakes and coastlines (including many ecological fragile eco-regions), high solar irradiance, and world-class green hydrogen potential, the building blocks for a sustainable ferry revolution are already in place.

The path forward will require bold action. Governments and municipalities across LATAM must pair vision with pragmatism—launching pilot projects, modernizing infrastructure, and creating policy frameworks that align national climate commitments with local mobility needs. Public-private partnerships will be essential, bringing together international expertise, local shipbuilders, and innovative technology providers. Likewise, leveraging climate finance from multilateral institutions such as the Green

ned-for-brazilian-port-tugs-84525

37 *Ibíd*

38 https://biodieselmagazine.com/articles/incat-crowther-to-design-renewable-diesel-ferry-for-los-angeles-catalina-express

39 https://kentico.portoflosangeles.org/getmedia/5232f369-9b5f-4c15-a4b4-24e6230f2b00/05_1-16-25-BHC_Item-5-Environmental_-Environmental_CARB-LA-MER-Grant-Subrecipients

40 https://www.rivieramm.com/news-content-hub/news-content-hub/biofuel-trial-planned-for-brazilian-port-tugs-84525

Climate Fund, CAF, and the IDB can help bridge initial capital cost gaps and accelerate deployment.

By replacing or retrofitting aging diesel fleets, cities can deliver cleaner air, quieter waterways, and more reliable transport for underserved communities, while contributing to national emissions-reduction targets. Examples from around the world—including early deployments in Latin America including the battery-electric ferry service between Buenos Aires-Uruguay to solar-powered ferry pilots on Argentina's Paraná River and Rio de La Plata —demonstrate that technological feasibility is no longer a barrier; what remains is the political will and coordinated action to scale solutions.

Latin America's rivers, bays, and coastlines are not obstacles to connectivity—they are strategic assets. With decisive leadership, the region can transform its "blue corridors" into engines of sustainable growth, equitable access, and climate action that could spur more sustainable maritime urban transport and expanded eco-tourism. The opportunity is here, the technology is ready, and the tide is already turning toward a cleaner, water-connected urban future.

Photo caption: Launch of China Zorrilla, the e-ferry operated by BoqueBus offering service between Buenos Aires, Argentina and Colonia Sacramento, Uruguay. Photo Credit: INCAT Tasmania, 2025

Author: Lawrence Youngblood

Global Trends in Hydrogen Terrestrial Transport & California Lessons Learned

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Credit: Alamy Stock Images

Executive Summary

This chapter evaluates global trends in hydrogen-powered terrestrial transportation highlighting advances California with specific examples illustrative of the successes and challenges in the application of this relatively nascent yet promising clean energy technology. Leveraging recent advances in infrastructure, public-private partnerships, and state and federal programs, California stands at the forefront of hydrogen adoption for transport. Yet the state's momentum faces headwinds from newly rescinded federal waivers, rollbacks under the Trump administration, and evolving regulatory uncertainty. The analysis concludes with recommendations to bolster hydrogen deployment despite federal policy shifts.

Hydrogen Typologies and Global Trends

Hydrogen is a *secondary energy carrier,* created from primary energy sources such as natural gas, renewables, and even nuclear. Because it can be produced in different ways, it takes on different typologies, but it is most commonly discussed in its grey, blue, and green forms.

- **Grey Hydrogen** – Produced from natural gas (methane) via steam methane reforming (SMR) without capturing CO_2.
- **Blue Hydrogen** – Considered low-emission. Produced the same way as grey hydrogen (SMR from natural gas) but paired with carbon capture and storage (CCS).
- **Green Hydrogen** – Considered low-emission. Produced via electrolysis of water powered by renewable electricity.

Of these three, **grey hydrogen dominates** the global market, accounting for an estimated 95% of total production[41]. This is noteworthy in the context of hydrogen's role in decarbonization, as most hydrogen today still depends heavily on fossil fuels. Also, there is significant energy loss associated with hydrogen fuel production. The IEA's 2024 Global Hydrogen Review suggests that while low-emission hydrogen project announcements indicate strong growth for the sector in the coming years, numbers still fall short of targets set out in zero-emission roadmaps where hydrogen plays a key role.

Despite early enthusiasm for hydrogen-fueled transportation, technological progress has been slow, and global investment and deployment remains largely tepid due to high infrastructure capital expenditure requirements, uncertain demand forecasts, and competitive alternatives.[42] IEven with these barriers, low-emission hydrogen continues to be identified as an essential tool for achieving deep decarbonization, especially within the transportation sector.

41 https://arxiv.org/abs/2410.08154
42 https://www.iea.org/reports/global-hydrogen-review-2024/

Around the world, "hydrogen hubs" (H2 hubs) are emerging as integrated ecosystems where production, storage, distribution, and end-use are co-located to improve cost efficiency and accelerate adoption. These H2 hubs leverage public-private partnerships, co-deployment of infrastructure, and targeted applications in sectors where hydrogen offers a competitive advantage – primarily heavy-duty freight, public transit, maritime transport, and industrial processes.

In **Asia**, Japan's Fukushima Hydrogen Energy Research Field (FH2R) produces 10 MW of green hydrogen from renewables, supplying mobility fleets and grid services[43]. South Korea's Ulsan hub integrates offshore wind-powered electrolysis with urban transit[44]. Also, China is actively building out re-fueling stations and deployment of hydrogen busses and trucks. In fact, last year China outpaced the rest of the world in the production of hydrogen heavy duty vehicles. Also, according to the Financial Times, China also leads the world in hydrogen commercial vehicle sales[45].

In **Europe**, Germany's H_2 Mobility network is shifting focus to infrastructure that supports the refueling of commercial hydrogen vehicles, predicting a wane in demand from H2 cars[46]. The Netherlands' HEAVENN project connects large-scale electrolysis with buses, trucks, and industrial users[47], while Rotterdam port works to become Europe's focal point of hydrogen imports and exports[48]. The development of the EU's hydrogen transportation infrastructure has been catalyzed, in part, by the EU's AFIR law requires hydrogen refueling on the TEN-T core network every 200 km and in all urban nodes by 2030—explicitly sized for heavy-duty vehicles.[49]

Oceania has Australia's Geelong hub which boasts multi-bay truck refueling with green hydrogen produced by the region's abundant solar and wind resources[50]. Also, work is underway to develop a government backed "hydrogen highway" along the New South Wales-Victoria Hume corri-

43 https://www.global.toshiba/ww/news/energy/2020/03/news-20200307-01.html
44 https://fuelcellsworks.com/news/ulsan-city-leads-the-way-hydrogen-trams-to-transform-urban-transit-by-2029
45 https://www.ft.com/content/41fe6407-ca14-4bf3-b5ee-0163c0b4888c?
46 https://www.electrive.com/2025/03/03/h2-mobility-to-shut-down-22-hydrogen-fuel-stations-in-germany/
47 https://heavenn.org/green-mobility/
48 https://www.portofrotterdam.com/en/port-future/energy-transition/ongoing-projects/hydrogen-rotterdam
49 https://ec.europa.eu/commission/presscorner/detail/es/ip_23_4782 1/5
50 https://www.news.com.au/technology/motoring/on-the-road/australias-first-green-hydrogen-refuelling-station-opens-in-geelong/news-story/10626eb2e386a97189c8b075d354ea47

dor with an extensive hydrogen refueling network.[51]

In **North America**, U.S. DOE's Regional Clean Hydrogen Hubs program has funded seven hubs, including California's ARCHES, focused on ports, heavy trucking, and public transit. While plans for ARCHES are still moving forward, the Trump administration has proposed terminating four hubs across the United States (including ARCHES) and $4 billion in support, a decision expected to be called in the coming months[52]. Canada's Hydrogen Corridors Initiative is decarbonizing freight by way of hydrogen-powered trucking routes through western provinces[53].

Across Africa, countries are capitalizing on their world-class solar resources. In Namibia, large-scale green hydrogen projects such as Hyphen and Arandis are being developed to produce ammonia and support applications[54], including maritime transport[55].

In **Latin America and the Caribbean (LAC)**, early-stage H2 hubs are forming. **Chile's Magallanes region** is developing large-scale wind-powered electrolysis to be used domestically for mining fleets. Additionally, with its intense solar radiation and powerful winds, the Magallanes region is poised to become one of the world's lowest-cost hydrogen producers and aims to be a world leader for hydrogen exports[56]. **Colombia** is also advancing green hydrogen pilots in Cartagena's industrial zone and working to roll out a hydrogen bus fleet in Bogotá[57]. **Trinidad and Tobago** is also exploring blue hydrogen production leveraging its pre-existing natural gas infrastructure[58], , while Costa Rica operates a small renewable hydrogen cluster in Liberia supplying buses and industrial vehicles[59]. In Uruguay, a group of companies has invested USD$38.6 million in the nation's first green hydrogen plant, known as Kahirós and located in Fray Bentos, which will be operation in 2026 and used to fuel heavy-duty trucks transporting timber[60]. The project will include 8,000 solar panels, a 2MW electrolyzer and a truck re-fueling station[61].

For LAC, these examples highlight the value of starting with existing fleets and aligning hub design with abundant renewable resources, port infrastructure, and export potential. LAC was singled out in the IEA 2024 Global Hydrogen Review as holding significant promise in the emerging low-emission hydrogen market. Capitalizing on its bountiful natural and renewable resources, combined with a relatively decarbonized grid, the region can focus on domestic applications to scale up production, positioning itself to capitalize when the historically slow-growing global hydrogen market begins to expand[62].

California's Hydrogen Ambitions & Lessons Learned:

California has been an early innovator in promoting hydrogen transport options and these efforts have been bolstered by a consistent trend of government support. In 2004 the state began the *'Hydrogen Highway Initiative'* under Governor Schwarzenegger, which aimed to establish a network of 150 fueling stations and support the adoption of 20,000 hydrogen-powered vehicles by 2010. Although the initiative fell short of these ambitious targets due to a lack of sustained funding, it established a foundational policy and infrastructure framework that positioned the state as an early leader in hydrogen adoption.

California's focus has been primarily on accessibility of hydrogen, subsidizing its higher infrastructure and distribution costs, allowing it to maintain a viable status in zero-emission vehicle options as California tightens the reins on emission standards.

Even with continuous state support, California's hydrogen sector has progressed in a non-linear fashion. Key lessons from their journey can be applied to regions aiming to expand their own hydrogen networks, helping them avoid the mistakes made by earlier trailblazers. For one, avoid deploying H_2 networks where battery electric will outcompete. Light-duty H_2 vehicles come nowhere near cost parity with EVs and volatile prices can lead to fuel-station closures while demand is uncertain. Hard to abate

51 https://hvia.asn.au/hydrogen-superhighway-to-link-eastern-states/
52 https://natlawreview.com/article/shifting-energy-priorities-are-reshaping-h2hubs-program
53 https://www.hydrogen.ca/what-we-do/western-canada-hydrogen-corridors-initiative
54 https://namibiatoday.com/cleanergy-to-invest-n50-billion-in-arandis-green-hydrogen-project-advancing-namibias-renewable-energy-goals/
55 https://fuelcellsworks.com/news/namibias-green-hydrogen-projects-reach-key-milestones
56 https://energia.gob.cl/sites/default/files/documentos/green_h2_strategy_chile.pdf
57 https://hydrogenindustryleaders.com/colombias-first-hydrogen-powered-buses-experience-continued-delays/
58 https://publications.iadb.org/en/publications/english/viewer/The-roadmap-for-a-green-hydrogen-economy-in-Trinidad-and-Tobago.pdf
59 https://www.oecd.org/content/dam/oecd/en/about/programmes/cefim/green-hydrogen/update-case-studies/Ad-Astra-Case-Study-2024.pdf/_jcr_content/renditions/original./Ad-Astra-Cas
60 https://renewablesnow.com/news/uruguays-1st-green-h2-project-takes-shape-production-seen-in-2026-873180/
61 https://yieh.com/en/News/uruguay-announces-plans-for-first-green-hydrogen-plant/151049#:~:text=Register-,Steel%20News,US$ 1.3%20billion%20in%20exports.
62 *AIE, Revisión Global del Hidrógeno 2024*

sectors like drayage, heavy-duty trucking, and long-distance transit are the most reliable base to build hydrogen projects around, with opportunity to expand into tangential markets in the future. Another crucial takeaway is to avoid tying project viability to one credit market; California's retail stations struggled as LCFS credit prices swung, exposing operations to revenue shocks[63]. Programs should be designed to remain viable even if credit values collapse. Realistic water and energy demand must be assessed. Low-emission hydrogen is energy intensive and water demanding to produce – a big ask for regions exposed to grid issues or frequent droughts[64].

Lastly, diverse sources ensure supply security. California's hydrogen market has experienced multiple supply delays or outages, disrupting the status quo necessary to have hydrogen be a reliable fuel[65].

Policy Environment for Hydrogen in California

California's Low Carbon Fuel Standard (LCFS) is the cornerstone policy supporting the state's hydrogen deployment. Administered by The California Air Resources Board (CARB), it requires progressive carbon-intensity reductions and rewards low-carbon fuels with tradable credits. Hydrogen producers and station operators earn LCFS credits, offsetting costs.

The California Energy Commission (CEC) funds station while the Clean Truck and Bus Voucher Incentive Project (HVIP) vouchers support point-of-sale purchases of hydrogen buses and trucks, making for a more affordable sticker price for fleet owners[66].

CARB oversees vehicle emissions standards and zero emission vehicle (ZEV) mandates, operating under a Clean Air Act waiver which, until recently allowed California to uphold higher standards than federal law requires. CARB has adopted the Advanced Clean Trucks (ACT) Regulation,

63 *https://ww2.arb.ca.gov/sites/default/files/2023-12/AB-8-Report-2023-FINAL-R.pdf*
64 https://climateprogramportal.org/wp-content/uploads/2025/02/Pathways-to-Commercial-Liftoff_Clean-Hydrogen_December-2024-Update.pdf
65 https://www.greencarreports.com/news/1130717_another-fuel-cell-outage-hampers-bay-area-fuel-cell-drivers
66 https://www.energy.ca.gov/publications/2025/joint-agency-staff-report-assembly-bill-126-2024-annual-assessment-hydrogen

which stipulates that manufacturers must sell an increasing percentage of zero-emission trucks (battery-electric or hydrogen fuel cell), which started in model year 2024[67]. CARB has also put in place the Advanced Clean Fleet (ACF) Regulation, which requires long-haul trucking companies to have an increasing percentage of their fleet be ZEVs beginning in 2036[68]. This state mandate has, however, recently been rolled back due to recent Federal actions by the Trump Administration[69].

In July 2024, California formally launched the ARCHES hydrogen hub, securing $1.2 billion in federal funding under DOE's Regional Clean Hydrogen Hubs program. As previously mentioned, the program has uncertain days ahead of it as it faces a new administration, but should it survive the hub targets decarbonizing ports, heavy-duty freight, and mass transit—representing 2 million metric tons of CO_2 avoided annually[70].

Californian Ports Lead the Way

Port of Long Beach Toyota and FuelCell Energy TriGen facility[71]. Picture: Courtesy of the Port of Long Beach.

Seaports are currently demonstrating the use of hydrogen and fuel cell technologies for port operations throughout California. One primary example of these technologies is heavy-duty drayage trucks powered by hydrogen that deliver port containers to inland destinations. Here, the

67 https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks/about
68 https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/about
69 https://subscriber.politicopro.com/article/eenews/2025/06/12/trump-signs-rollback-of-california-ev-mandate-00402826
70 https://www.gov.ca.gov/2024/07/17/california-launches-world-leading-hydrogen-hub/
71 https://polb.com/port-info/news-and-press/renewable-energy-project-powers-port-with-hydrogen-05-02-2024/

Port of Los Angeles utilizes ten drayage trucks manufactured by Kenworth using Toyota fuel-cell electric technology. Originally deployed to test feasibility of these hydrogen truck models, they are still in use today[72].

At the Port of Long Beach, Shell operates a heavy-duty hydrogen station supporting local freight operations. Toyota and FuelCell Energy's Tri Gen facility nearby produces renewable hydrogen from biogas (≈1,200 kg/day), combined with power and water co-generation—exemplifying effectively integrated, multi-service hydrogen facilities[73 74].

At the Port of Oakland, thirty Hyundai fuel-cell electric drayage trucks are operating at full commercial capacity. To support the refueling of these fuel cell electric drayage trucks three hydrogen fueling stations capable of serving zero-emission heavy-duty trucks, including the largest of its kind, are in service or under construction adjacent to the Port of Oakland[75].

Heavy-Duty Trucking Corridors

California's hydrogen fueling network for Class 8 long haul trucks is expanding. Facilities along freight corridors include Nikola's HYLA network and FirstElement hubs, which are filling out a plan to install up to 60 hydrogen fueling stations throughout California[76]. In 2024, California, Oregon, and Washington received $102 million in federal funding to deploy hydrogen fueling stations along Interstate 5, a premier West Coast trucking corridor. These initiatives demonstrate the combined public and private support that hydrogen continues to attract through incentives such as LCFS credits and capitalization federal funding during supportive administration periods..

72 https://pressroom.toyota.com/trucking-world-endorses-toyotas-hydrogen-powered-fuel-cells-as-a-step-toward-a-cleaner-planet/
73 https://pressroom.toyota.com/trucking-world-endorses-toyotas-hydrogen-powered-fuel-cells-as-a-step-toward-a-cleaner-planet/
74 https://www.fastechus.com/case-studies/shell-hdv-long-beach
75 https://www.portofoakland.com/wp-content/uploads/2024/06/Project-Narrative_Port-of-Oakland.pdf
76 https://www.nikolamotor.com/nikola-opens-first-hyla-hydrogen-refueling-station-in-southern-california

Zero-Emission Public Transit

It is important to recognize that California fleets are allowed to wield discretion as to which technologies they will implement to reach CARB emission standards. California regional transit agencies like AC Transit, SunLine, and Foothill Transit have opted to advance their hydrogen.

AC Transit received $144 million through ARCHES expressly designated to hydrogen fleet expansion[77]. SunLine's hydrogen bus fleet has accumulated 3.3 million miles as of the start of 2025, citing lower maintenance costs and durability in extreme heat as valuable attributes of fuel cell electric transport[78]. Foothill transit owns and operates 33 hydrogen fuel cell buses with an intended 19 more to be added in the coming years. These buses offer an extended range of roughly 300 miles compared to battery electric and reduce GHG emissions up to 135 tons per year compared to a diesel bus[79].

The interest in hydrogen for public transit originated with the state's Innovative Clean Transit (ICT) goals, which set a target of 100% zero-emission bus use by 2040[80].

Policy Challenges

Under the first Trump administration (2017–2021), reduced federal clean-energy support slowed some projects, though California maintained inertia through state-level investment. Moving forward, cost reduction, infrastructure growth, and cross-sector partnerships will be crucial for mainstream adoption amidst a broader dismissal of hydrogen transport technology.

Under the Trump administration's recent actions, Congress revoked California's waiver under the Clean Air Act that historically enabled the state to enforce stricter emission standards, nullifying EV sales mandates (e.g.

77 https://www.actransit.org/article/ac-transit-receives-144-million-for-zero-emission
78 https://www.sunline.org/projects/alternative-fuels/clean-fleet
79 https://www.foothilltransit.org/greeningbig
80 https://ww2.arb.ca.gov/resources/fact-sheets/innovative-clean-transit-ict-regulation-fact-sheet

ban on new gas powered cars by 2035) and heavy-duty truck emissions rules[81]. California citizens and fleet owners alike will now be faced with the decision of upgrading to ZEVs and maintaining state goals or residing with the often more affordable combustion engine options..

Comparative Advantages and Challenges of Hydrogen vs Battery EVs

The following table compares key evaluation criteria for heavy-duty trucking between hydrogen fuel cell trucks and battery-electric trucks based on vehicles operating on California roadways.

Though it simplifies the tradeoffs between the two technologies, does not consider the state and U.S. federal support which could bias fleet owners, and neglects other forms of terrestrial transportation, it is a helpful way to visualize the key differences between these options. .

Criteria	Hydrogen FCEV Trucks	Battery-Electric Trucks (BEVs)
Average Vehicle Cost	$750,000–$1,200,000[82 83]	$400,000–$500,000 (declining with scaling)[84]
Refuel / Charge Time	10–20 minutes (similar to diesel fueling)[85]	2–8 hours (1–2 hrs with megawatt DC fast charging)[51]
Range	300–500 miles typical; demonstrations target 600+[51]	150–300 miles typical; up to 400+ with next-gen batteries[86]
Maintenance Costs	Moderate – likely better than diesel[87]	Lower – fewer moving parts, lower servicing costs vs. diesel[53]
Vehicle Weight	Lighter than BEVs (allows for higher payload)[88]	Heavier; large batteries reduce payload capacity[56]

81 https://www.politico.com/news/2025/06/12/trump-revokes-californias-nation-leading-electric-vehicle-mandate-00402601
82 https://www.wsj.com/articles/nikolas-rollout-of-hydrogen-trucks-is-hitting-supply-chain-hurdles-322823c2
83 https://www.sunline.org/projects/alternative-fuels/clean-fleet
84 https://ww2.arb.ca.gov/sites/default/files/2024-12/Zero%20Emission%20Class%208%20Tractor%20Pricing%20Comparisons_ADA.pdf
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86 https://mexicomlogistics.com/electric-trucks-north-america-drigins-range/
87 https://www.globaltrademag.com/the-rise-of-electric-and-hydrogen-powered-trucks-in-sustainable-logistics/

Lessons Learned & Recommendations for LAC:

California's hydrogen rollout serves as a large-scale pilot project, offering valuable insights into what works and what does not. Hydrogen should first be targeted at freight "hubs and corridors" such as drayage, mining, and long-haul trucking where battery-electric vehicles are limited by range and payload. Vehicles, fueling stations, and supply chains must be planned together, ideally co-sited with industrial demand at ports, refineries, or cement and steel clusters to guarantee steady offtake. Policy should also mandate reliability from the outset by requiring multiple supply pathways and supportive subsidies.

To avoid the pitfalls California faced, LAC countries should design market supports that de-risk revenue exposure by protecting operators from credit volatility through mechanisms such as price floors or contracts-for-difference. Governments should adopt a technology-neutral approach, allowing buses and regional delivery fleets to opt battery-electric unless independent cost and efficiency screens clearly favor hydrogen. Finally, planners must account for water and grid constraints by tying electrolyzers to reclaimed water where possible and contracting sufficient renewable electricity to cover production, compression, and chilling. These steps can help LAC build a resilient, cost-effective hydrogen ecosystem while sidestepping the challenges that slowed California's hydrogen network buildout.

88 https://www.symbio.one/en/news-media/newsroom/hydrogen-truck-vs-electric-truck-which-best-solution-future-your-fleet

Electric Mobility Policies in Brazil: Progress, Challenges, and Outlook to 2034

Brazil is experiencing a strategic moment in the energy transition, and electromobility is emerging as a key vector for the decarbonization of the transportation sector. The presentation of the Energy Research Company (EPE), linked to the Ten-Year Energy Expansion Plan 2034 (PDE 2034), offers a solid analysis of the current scenario and the perspectives of public policies on electric mobility in the country.

National and international perspectives

In 2023, global EV sales reached 14 million units (18% of the total), driven by government incentives, falling battery prices, and increased model availability. In Brazil, the situation is more moderate: electric vehicles (HEV, PHEV, and BEV) account for approximately 4.3% of registrations, concentrated in the premium segment due to the high cost of these models and the still incipient infrastructure.

Initiatives and Public Policies

The country has invested in a set of policies to promote electromobility:

- The MOVER Program: Incentivizing Domestic Production of Cleaner Vehicles.
- New PAC: Allocating R$ 7.3 billion through 2028 for the renewal of electric bus fleets in 61 municipalities.
- Future Fuel Program: seeks to integrate biofuels into the decarbonization strategy, without limiting the country to a single technology.

These actions, in combination with RenovaBio, Proconve, Rota 2030 and PBEV, promote a neutral and gradual technological approach.

National Market Trends

Progressive progress in electrification is expected:

- Light Vehicles: Registrations of 694,000 electrified units are projected for 2034, representing 18% of sales. The total fleet of hybrid and electric vehicles is expected to reach 3.7 million.

- Light Commercial Vehicles and Light Trucks: These vehicles are expected to lead the electrification of urban freight transport, accounting for 16% of projected sales in 2034.
- Urban buses: It is estimated that 26% of sales will be reached by 2034, driven by municipal policies and the New PAC (Advanced Growth Acceleration Program).
- Heavy and light-duty vehicles: A gradual advance in electrification is expected, with a predominance of diesel and a growth in hybrid and natural gas alternatives.

Structural Challenges

Despite progress, Brazil still faces significant obstacles:

- Charging Infrastructure: Although it has grown, with more than 10,000 charging stations projected by 2025, coverage is still insufficient, especially outside major cities.
- High Cost: The best-selling electric vehicles have an average price of R$ 243,000, limiting their adoption to higher-income consumers.
- External Dependence: Approximately 65% of electric vehicles sold in Brazil in 2023 were imported from China and Japan.
- Fiscal and Energy Impacts: Electrification reduces tax revenues from fossil fuels and can overburden the power grid if not properly planned.

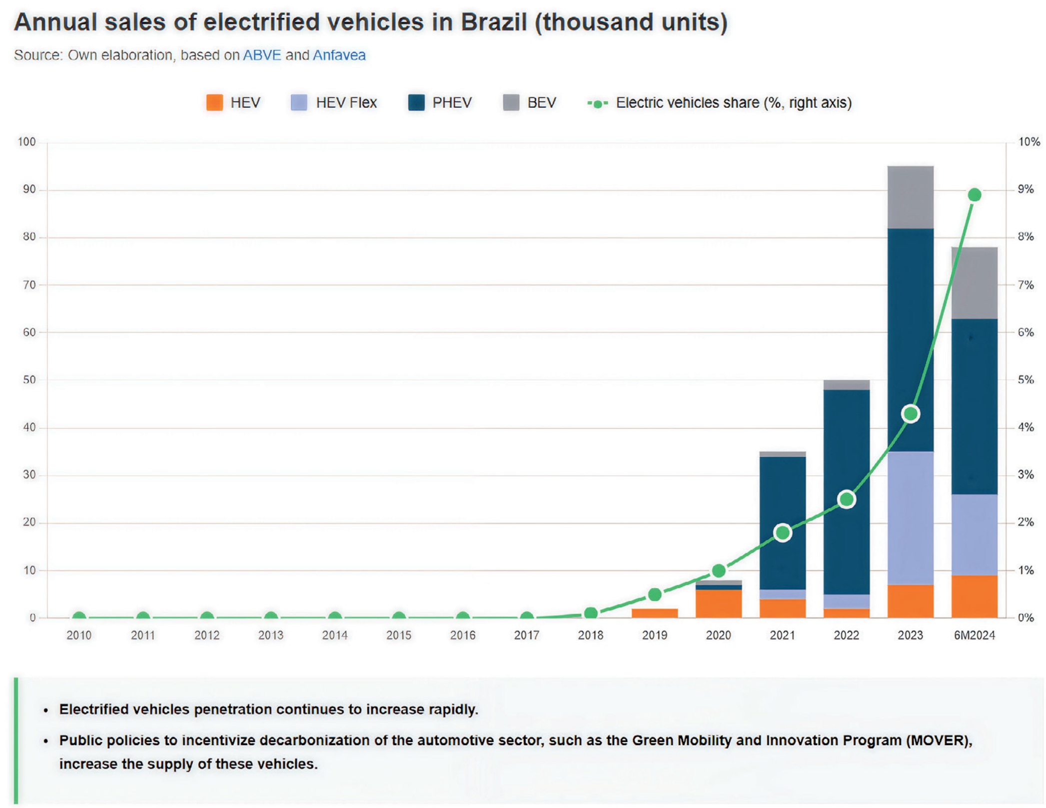
Production and Strategic Perspectives

Brazil has attracted approximately R$130 billion in announced investments by automakers through 2030. Among the most prominent investments are Stellantis, Volkswagen, BYD and Hyundai. The country also has important reserves of strategic minerals such as nickel, graphite, manganese and rare earths, essential for the local production of batteries.

Graphs on the Growth of Electric Mobility in Brazil:

Electric Vehicle Adoption in Brazil: Trends and Projections (2010–2024):

Visualize the growth of the share of hybrid electric (HEV), plug-in hybrid (PHEV), and battery-electric (BEV) vehicles in total sales..

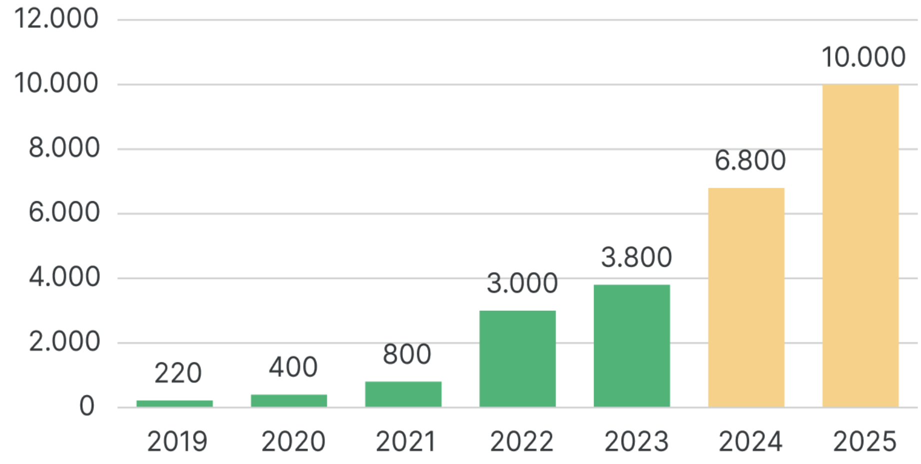


Source: ABVE, Anfavea.

Charging infrastructure in Brazil (2019-2025):

Shows the increase in public and semi-public charging stations and concentration by region

Charging infrastructure in Brazil (2023)
Source: ABVEapudAnuário2023 daPNME



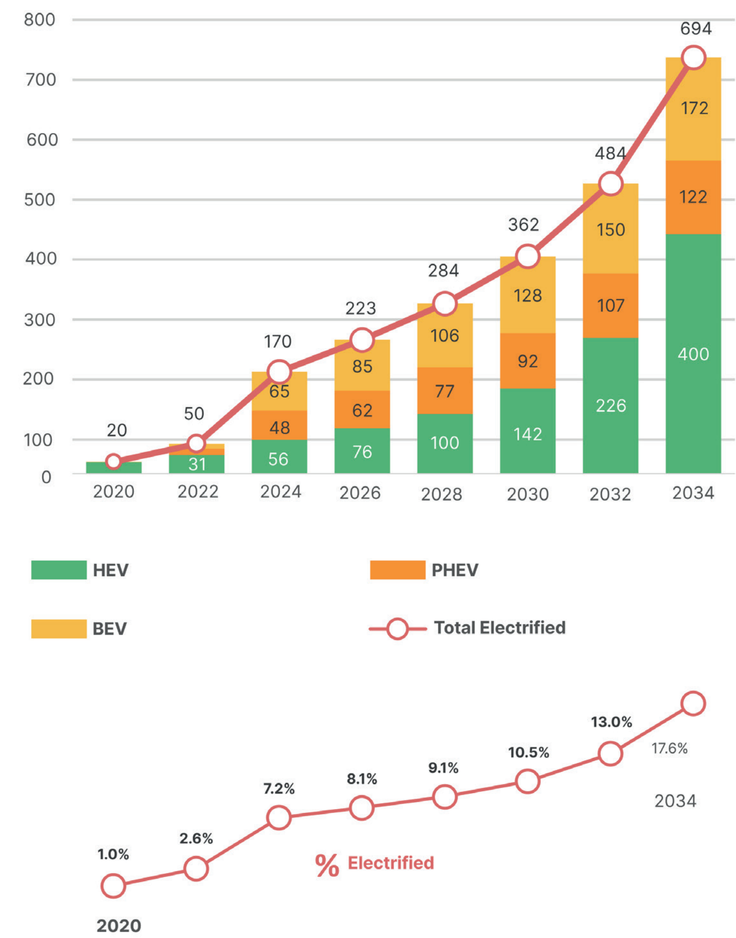
- The number of public and semi-public charging stations is growing, with an even greater increase expected for the next two years
- However, it still proves insufficient for a country of continental size like Brazil.

Source: PNME.

Projection of Electric Vehicle Registrations by Category (2020–2034):

It shows the estimated growth of hybrid electric (HEV), plug-in hybrid (PHEV), and battery-electric (BEV) vehicles.

Registration of light hybrids and electric vehicles (thousands of vehicles, % of total)
Source: EPE



Fuente: EPE

Conclusion

Electric mobility in Brazil is progressing gradually and selectively, balancing the adoption of new technologies with the use of already established biofuels. For electrification to reach greater scale and reach all segments of the population, it will be necessary to expand infrastructure, facilitate access to financing, strengthen local industry and guarantee the energy security of the national electricity system.

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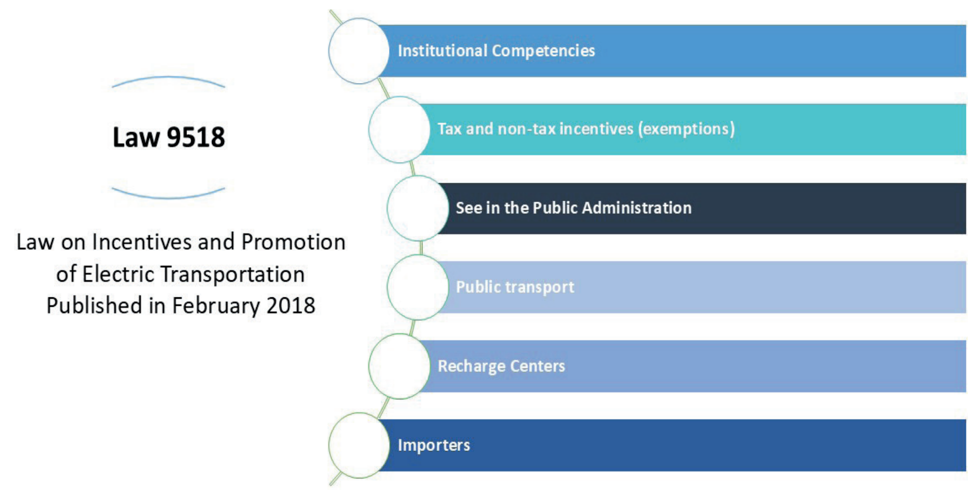
- ABVE. Statistical data. https://abve.org.br/abve-data

Electric Mobility in Costa Rica

Public Policies

In Costa Rica, following the enactment of the Law for Incentives and Promotion of Electric Transport, Law No. 9518 and its amendments, the public policy framework for electric mobility has been developed. This Law was officially published on February 6, 2018, and amended by Law No. 10209 (reform that makes specific changes to the Incentives chapter). The following graph shows the general structure of Law No. 9518.

Outline of the Law for Inventions and Promotion of Electric Transport



Publication: La Gaceta No.22, Reach No.26, February 6, 2018

Based on the Law, several regulations are developed in order to comply with specific mandates of the Law. The regulations are detailed below:

- Executive Decree No. 41426-H-MINAE-MOPT, Incentives for Used Electric Vehicles. In which the import of used electric vehicles (EVs) is encouraged through exemptions, with the aim of advancing electric mobility faster.
- Executive Decree No. 41580-MJ-MINAE-MOPT, Regulation of badges for electric vehicles. Which establishes that the license plate of an EV will be green, so that it can be easily identified. This green plate has also become an incentive, a support mechanism for relief bodies in the case of emergencies occurring with EVs.
- Executive Decree No. 41642-Regulation for the construction and operation of the network of electric recharging centers for electric cars by electric power distribution companies. This decree establishes the guidelines for the installation of fast chargers in the country, indicating by area the minimum number of chargers that should exist.
- Executive Decree No. 42489-MINAE-MOPT-H, Regulations for the exemption of sales tax and selective consumption tax on spare parts for electric vehicles and exemption from selective consumption tax and 1% on customs value for parts and recharging centers. This decree has allowed the import of parts and spare parts for EVs, promoting access to users of spare parts locally.

On the other hand, and as part of the country's policies, it is important to mention that in article 2 of Law No. 9518, electric vehicle is defined as: "any movable property powered by one hundred percent electric energy or zero-emission technology and that does not contain a combustion engine, new, in its version of cars, motorcycles, bicycles, microbuses, buses, trains and any other defined in the regulations of this law". Therefore, all public policies are aimed at the promotion of 100% electric vehicles and zero emissions. Likewise, in the Decarbonization Plan 2018 - 2050, goals are established to migrate towards electric mobility (100% electric and zero emissions), specifically in Axis 2, the transformation of the fleet of light vehicles to zero emissions is included, nourished by renewable energy, not of fossil origin. In line with the above, for Costa Rica hybrid vehicles are not considered as objects of the benefits established by Law No. 9518 or the Decarbonization Plan, since they do not comply with being 100% electric or zero emissions by having a combustion engine.

Electric Vehicles in Costa Rica

EVs, like any other type of vehicle entering the country, must comply with the import and nationalization processes already established at the national level. Once the vehicle is nationalized, and has the technical vehicle inspection, it is registered with the National Registry. Registered vehicles are the basis of relevant information at the national level for the purposes of accounting for advances in electric mobility. The following link shows the data of the EVs that are registered in the country: https://www.minae.go.cr/ver/energia/Datos %20TOTALES-VEs-publicacio´n.pdf.

The following table shows the EVs registered for the year 2025.

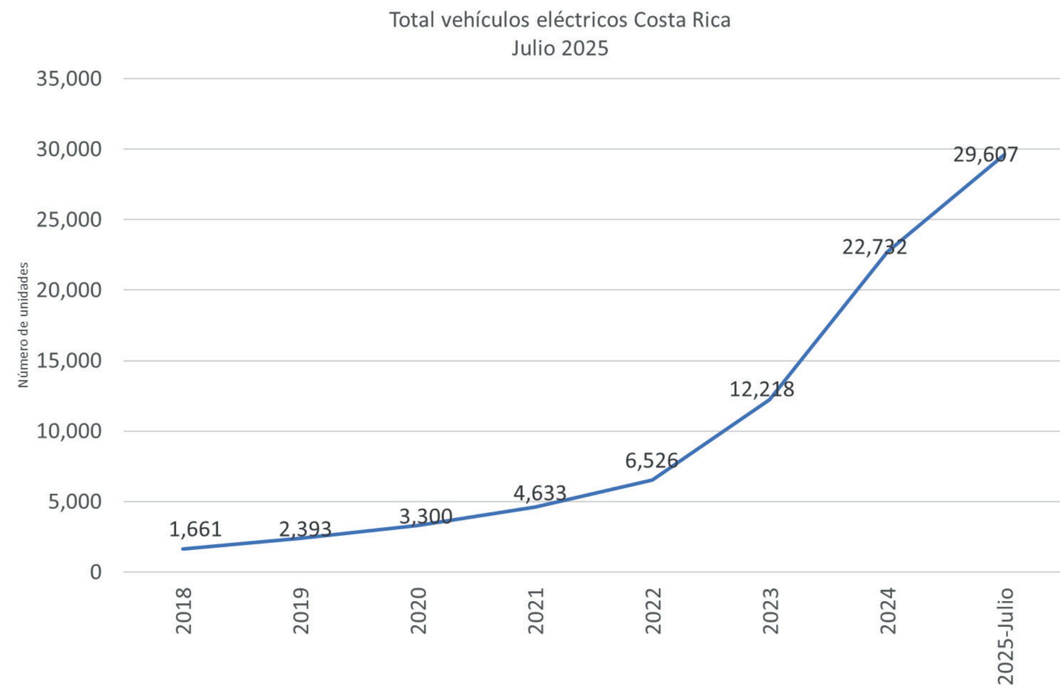
Table 15. Electric vehicles registered in Costa Rica, year 2025

MONTH	AUTO-MOBI-LES	MOTORCY-CLES	SPECIAL	LABOR	TOTAL	% REG.
January	613	0	27	17	657	10.56%
February	677	0	12	32	721	16.42%
March	569	0	11	18	598	14.01%
April	605	0	5	13	623	15.44%
May	886	0	79	23	988	18.23%
June	679	1	11	25	716	14.29%
July	619	1	6	34	660	14.53%

Source: Directorate of Energy, MINAE, based on data from the National Registry

As can be seen in the table above, the average number of registered EVs exceeds 14% of the total number of vehicles registered in Costa Rica for the year 2025.

Table 16. Total electric vehicles as of July 2025 in Costa Rica



Source: Directorate of Energy, MINAE, based on vehicle data registered in the National Registry. Author's original image.

Similarly, by July 2025, a total of 29,607 EVs have been registered. This figure includes EVs registered since 2018, which is taken as the baseline year due to the enactment of Incentives Law No. 9518. The main increase in electric mobility occurs in the automobile category (light vehicle and SUV), which accumulates a total of 24,668 for the month of July 2025 (called "Cars" in Table 15).

The data presented above are updated monthly by the Energy Directorate of MINAE, in order to show the progress of electric mobility, as well as the behavior of the acquisition and import of EVs in the country. Likewise, the data is available according to the type of vehicle category, to reflect the growth in each category of vehicles, as established by Law No. 9078, (Law of Traffic by Public Roads and Road Safety and its reforms).

Author: Aladda

Sustainable Mobility in Latin America: A Shared Commitment

ALADDA
Asociación Latinoamericana de Distribuidores de Automotores

Genaro Baldeón Herrera
President
Latin American Association of Automotive Distributors

Introduction

Mobility is one of the pillars supporting economic and social development in Latin America. Improving the way people and goods are transported within our cities and territories requires simultaneously addressing road safety, energy efficiency, fuel quality, fleet renewal, and the development of modern infrastructure The Latin American Association of Automotive Distributors (ALADDA) conceives of sustainable mobility as an engine to raise the quality of life, reduce inequalities and boost the competitiveness of the region.

Technological neutrality and diversity of solutions

The path toward more efficient mobility does not allow for single solutions. The diversity of energy, economic and social realities of our countries demands an approach of technological neutrality, which simultaneously promotes highly efficient electric, hybrid, hybrid, hydrogen, biofuels and internal combustion vehicles. The coexistence of these technologies ensures a balanced, viable transition adapted to the capabilities of each nation, avoiding economic disruptions that harm consumers and businesses.

Fuel quality and fleet modernization

One of the biggest challenges in Latin America is the low quality of fuels in several markets, which limits the introduction of modern technologies and increases polluting emissions. The experience of countries in the region that have adopted stricter standards shows that it is possible to move forward when there is political will and public-private coordination.

At the same time, the aging of the vehicle fleet constitutes a structural problem. In several countries, the average age of vehicles exceeds 15 years of use, which increases road risks and reduces energy efficiency. To reverse this situation, it is essential to implement scrapping programs, strict restrictions on the import of unsafe and highly polluting used vehicles, as well as financial incentives for the acquisition of new units or with clean technologies.

Infrastructure and Strategic Partnerships

Infrastructure underpins the transition. Power stations, fast-charging networks, biofuel and hydrogen stations, as well as modern public transport require large-scale investments. In this sense, public-private partnerships are the most effective mechanism to expand coverage, ensure equitable access and promote citizens' confidence in these technologies.

Overcoming current limitations requires coherent and sustained public policies that ensure inclusive and wide-ranging networks capable of sustaining the transformation towards cleaner and more efficient mobility.

Inclusive mobility: public transport and alternative modes

Sustainable mobility cannot focus solely on private vehicles. It is essential to promote decent, efficient and low-emission public transport, complemented by safe bicycle lanes and adequate pedestrian spaces. Only through urban planning that prioritizes the citizen will it be possible to face the chronic congestion that affects Latin American capitals such as Lima, Bogotá or Mexico City, where transfers of just 10 km can take more than 25 minutes.

The integration of these solutions not only improves air quality and road safety but also contributes to creating more livable cities.

Circular economy and waste management

The sustainability of the automotive sector also depends on responsible waste management. It is essential to promote tire and battery recycling, proper disposal of lubricants, and the reuse of materials. This vision of a circular economy strengthens consumer confidence, generates new business opportunities and contributes to reducing environmental impacts in the region.

Conclusion

Sustainable mobility in Latin America must be understood as a comprehensive strategy that articulates technological neutrality, quality fuels, modernization of the vehicle fleet, adequate infrastructure, dignified public transport, and responsible waste management. The success of this transformation relies on the convergence of governments, businesses, academia, and civil society.

At ALADDA, we reaffirm our commitment to work together to build a modern, inclusive and safe mobility ecosystem that raises regional competitiveness and improves the lives of millions of citizens in Latin America.

Author: Center for Sustainable Mobility of Chile

Clean Energy of Costa Rica

ELCO: Costa Rican Innovation at the Service of Sustainable Mobility

In an energy ecosystem increasingly marked by climate urgency and the need for decarbonization, charging solutions for electric vehicles have become consolidated as key pieces in the energy transition. In this context, the case of ELCO stands out, a Costa Rican company founded in 2015 that has managed to position itself as a regional benchmark in the manufacture of charging stations and the development of software for their management.

With a vision focused on the development of sustainable disruptive solutions and a strong commitment to local innovation, ELCO has demonstrated that it is possible to produce world-class technology from the region. Its mission goes beyond the simple manufacture of equipment: it seeks to represent the values and capabilities of Costa Rica through products that respond to the needs of a market in transformation.

Currently, ELCO has the only plant specialized in the region in the manufacturing of charging stations and a complete technological offer, ranging from portable charging stations to smart public stations, all designed with international standards (OCPP 1.6, among others) and designed for demanding conditions of use. Its main competitive advantages include an 8-year warranty -the highest in the current market-, 24/7 local technical support, and a customer service model focused on personalization and constant support.

In addition to hardware, ELCO has developed its own digital platform: ATILA, an application that allows real-time monitoring of the status and performance of more than 5,000 charging stations installed in Costa Rica. This tool -divided into a public app for drivers and an exclusive module for administrators- offers advanced functionalities such as load history, energy consumption analysis, user access control, precise control of energy consumption of electric fleets, remote updates, and even payment methods for the use of public fast charging network chargers in Costa Rica.

Its business model combines the sale of stations with a service approach, particularly in its private charging network, oriented to destination charging. Given the size and geographical conditions of Costa Rica, this strategy allows businesses such as hotels and restaurants to offer charging points as an added value, while encouraging new productive chains in rural communities. On the other hand, more than 90% of electric vehicle dealerships in Costa Rica use chargers manufactured by ELCO, which consolidates their leadership in the national market.

The company's strategic approach also includes regional expansion. Although it has already begun exporting to eight countries in the region, there are clear opportunities to expand its presence in Latin America and the Caribbean, particularly in areas where charging infrastructure is still underdeveloped. Its main strengths for this expansion include the adaptability of its products, its experience in energy management software and its vertical integration model.

However, like any emerging company in a constantly evolving sector, ELCO faces significant challenges. These include competition from low-cost imported products, and regulatory changes that may affect incentives for electric mobility, among others.

Nevertheless, ELCO's case demonstrates the transformative potential of the local industry when technical expertise, strategic vision, and purposeful innovation are combined. Within the framework of the energy transition, such companies are consolidating not only as solution providers but also as key players in building a new development paradigm for Latin America and the Caribbean.

Author: CLAEC

From Fuel Distributors

CLAEC

The role of CLAEC in the energy transition process and more sustainable mobility.e

The Latin American Fuel Entrepreneurs Commission (CLAEC) is the umbrella association composed of the associations of gas station owners, fuel retailers, or service station operators from Latin American countries.

CLAEC is a technical body that provides consultation and policy recommendations to various governments, generating and systematizing relevant information on the service station market in Latin America.

In Latin America there are approximately 100,000 Service Stations that mainly provide fossil fuels to their customers. However, at the Montevideo Summit, in September 2022, it was decided to accompany the different energy transition processes and transform the Service Stations into points of sale and supply of current and future energy.

The current scenario and especially the future implies a huge challenge for service stations in Latin America, but we decided to accompany this process as mentioned above.

Our countries have very different realities in terms of natural, social, and economic resources, infrastructure, and primary energy matrices. However, the gas station owners and fuel retailers that make up CLAEC share a common vision: they all aim to contribute to the general welfare, and work is being carried out toward that goal.

Currently, fuel stations in Latin America offer a mix of "traditional" fuels, natural gas for vehicles, biofuels, and electric vehicle chargers. In the future, it is likely that these energy sources will play a larger role in mobility, while new types of energy may also emerge to support the transition process.

The transition is a journey, and at CLAEC, we have chosen to take it.

Author: Center for Sustainable Mobility of Chile

Santiago de Chile: Latin American leadership in the transition towards 100% electric public transport

Melanie Andersen
Center for Sustainable Mobility of Chile

Santiago de Chile is a benchmark in urban electromobility, operating the largest fleet of electric buses outside China, with more than 2,500 units [1]. This achievement, reached in less than a decade, is based on long-term institutional planning that combines robust legal frameworks, innovative financing, and a strategic public-private vision. By March 2026, it is projected that 68% of the fleet will be electric, with around 4,400 units, further consolidating this global leadership.

A Track Record of Innovation and Sustainable Growth

The electrification of public transport in Santiago is the result of a long-term strategy, based on solid regulatory frameworks established since 2009. A key legal reform in 2015 solidified the viability of the model by classifying buses and terminals as "concessional assets," ensuring service continuity and protecting investments.

On this basis, Chile implemented a pioneering "provision of assets" model from 2016. This scheme was fundamental: by separating bus ownership and charging infrastructure from their operation, it decoupled the risk of direct investment for operators, attracting new investors and facilitating rapid expansion. This model began to take shape in 2017 with the operation of the first electric buses, marking the start of a rapid fleet expansion.

The expansion of electromobility in Santiago intensified with the redesign of the system to "Red Mobilidad" in 2019. The 2023 and 2025 tenders reinforced an innovative approach: they not only required 100% of new buses to be electric and integrated fleet provision with service operation but also separated terminal ownership from transport operators. This change was fundamental to eliminate the asymmetric bargaining power of operators vis-à-vis the authority and was made possible thanks to a strategic alliance with the state entity Desarrollo País, which was responsible for the acquisition of land and the development of infrastructure. This model has allowed a massive and efficient escalation.

The rapid adoption of electric buses has been supported by a significant investment in charging infrastructure, with 29 operating electro terminals (with a combined power greater than 100 MW) [1], projected to reach 56 electro terminals by 2026 [3].

Benefits and Impact of Transformation

The modernization of transport has generated a historic reduction in emissions between 2018 - when only 3% of the fleet was electric - and 2023, when it reached 30%. This progress resulted in a decrease of up to 62% in particulate matter emissions (PM2.5), 28% in CO_2eq [4], and 44% in noise pollution [2], the latter measure in a high-density public transport corridor.

In economic terms, the operating cost is at least 65% lower, and maintenance costs 44% less [2], resulting in substantial savings for the system. Added to this is a significant improvement in the user experience, with greater comfort, accessibility and connectivity, raising the standards of urban public transport.

This systemic change has been made possible thanks to exceptional inter-institutional coordination, led by the Ministry of Transport and Telecommunications and DTPM, with the support of the Ministry of Energy, distributors, and private operators. Mechanisms such as the possibility for operators to directly negotiate the purchase of energy with electricity marketers have encouraged more competitive and sustainable contracts, reflecting a vision of an integral city.

Challenges Towards Total Electrification and Regional Expansion

Although Santiago is a regional leader, the goal of electrifying 100% of its fleet and expanding the model to other regions of Chile presents critical challenges:

- **Infrastructure and Electrical Grid**: Ensure the scalability of the electrical system, coordinating with distributors to guarantee connection capacity. It is key to advance in standardization and technical approval and expedite processing times for new electro terminals.

- **Human Capital and Operation:** Strengthen the technical personnel specialized in maintenance and operation of electric buses, essential for long-term sustainability.
- **Financing and Regional Expansion:** Guarantee equitable access to financing for medium and small operators, adapting the model to regions with limited electrical infrastructure and terminals. This requires territorial planning, the development of scalable electro-terminals, and institutional strengthening.

Perspectives and Replicability

Santiago demonstrates that a transition of this magnitude is possible in Latin America, offering a valuable model for other cities. The Chilean experience encapsulates concrete lessons on how to align incentives, mobilize strategic investments, and generate tangible impacts on urban quality of life. Its success lies in political vision, rigorous technical management and sustained institutional coordination, critical elements for the global replicability of large-scale electromobility.

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Energy Efficiency Law

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Energy Efficiency Law

Context

One of the key tools to steer the market towards greater energy efficiency is **the implementation of Supply Side Regulations (SSR)**, as noted in the report prepared by the International Council on Clean Transportation (ICCT). These regulations focus on setting requirements for new vehicles to be marketed in the market and can take two forms: (1) electric vehicle sales mandates, or (2) minimum performance standards requiring new vehicles to meet average targets for energy efficiency or CO_2 emissions. For the light-duty segment, Chile chose the path of energy efficiency targets, and this report summarizes the regulatory design and its outcomes.

Chile has chosen to implement an energy efficiency standard through Law 21.305. This decision responds to a persistent challenge: in contrast to other countries, vehicle energy efficiency in Chile stagnated between 2013 and 2023 (see Figure 32), which has resulted in both higher emissions and higher operating costs in transport.

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Figure 32. *Vehicle performance between the years 2000 and 2023 in the EU, UK, US and Chile, measured in [km/lge].*

Regulatory framework

Law 21.305, enacted in February 2021, mandates the Ministry of Energy (MEN) to establish mandatory energy efficiency standards for light-duty (LDV), medium-duty (MDV), and heavy-duty vehicles (HDV), with deadlines set for 2022, 2024, and 2026, respectively. These standards are expressed in energy performance (kilometers per liter of gasoline equivalent, [km/lge]) and their compliance is the responsibility of each of the importers. Once published in the Official Gazette, the standards take effect within 24 months. Table 17 is presented below as a summary of regulatory deadlines..

***Table 17**. Regulatory deadlines according to Law 21.305 on vehicle standards.*

Segment	Publication year	Effective Date
Light-Duty Vehicles	2022	2024
Medium-Duty Vehicles	2024	2026
Heavy-Duty Vehicles	2026	2028

Source: Law 21.305, on energy efficiency.

Regarding the regulatory timelines for MDVs, the Ministry of Energy (MoE) published a new technical report in 2025. It also established that the entry into force of the standard will not be until April 2028, delaying implementation by two years.

The Law also defines the entities responsible for its implementation:

- Audit: Ministry of Transport and Telecommunications (MTT), through the Vehicle Control and Certification Center (3CV), in charge of measuring the energy performance of each vehicle approved in its laboratory.
- Sanctions: Superintendence of Energy and Fuels (SEC) of the Ministry of Energy (MoE).
- Publication of results: Ministry of Energy (MoE).

It also sets the theoretical amounts of fines and establishes an incentive mechanism that allows the energy performance of plug-in vehicles to be weighed up to three times in the calculation of the corporate average of each importer.

Standards for Light-Duty Vehicles

In February 2022, Exempt Resolution No. 5 established the first standards for LV, those whose gross vehicle weight is less than 2.7 tons:

- 2024 to 2026: 18.8 [km/lge].
- 2027 to 2029: 22.8 [km/lge].

- Since 2030: 28.9 [km/lge].

These values are applied as a reference standard, which is weighed on the annual fleet marketed by each importer. The required value for each importer is calculated from the reference standard, adjusted according to the average mass of the vehicles marketed by that importer. In practice, this means that importers whose fleets have a higher average weight face slightly less stringent requirements, while those with lighter vehicles are subject to stricter standards.

Industry Response to Proposed Light-Duty Vehicle Standard

During the public consultation, comments were received from 19 actors, including 10 importers and 3 national and international guilds or associations. In general, the opinions expressed that the proposal was excessively demanding and lacked sufficient transparency in its technical calculations, also considering the need for gradual implementation that would grant greater flexibility and allow incorporating corporate credit mechanisms. It was also noted that the lack of direct incentives for end users and the limited availability of charging infrastructure remain significant barriers to the widespread adoption of electric vehicles. Finally, several actors expressed concern about the risk of an increase in sales prices derived from fines in the event of non-compliance.

First Year Compliance (2024)

Performance of the different importers

29 LV importers were regulated in 2024 by the efficiency standard. Among these, 13 met (45%) and 16 did not meet (55%) the requirement. Figure 33 shows, for each importer, their requirement (in green) and the one achieved (in orange).

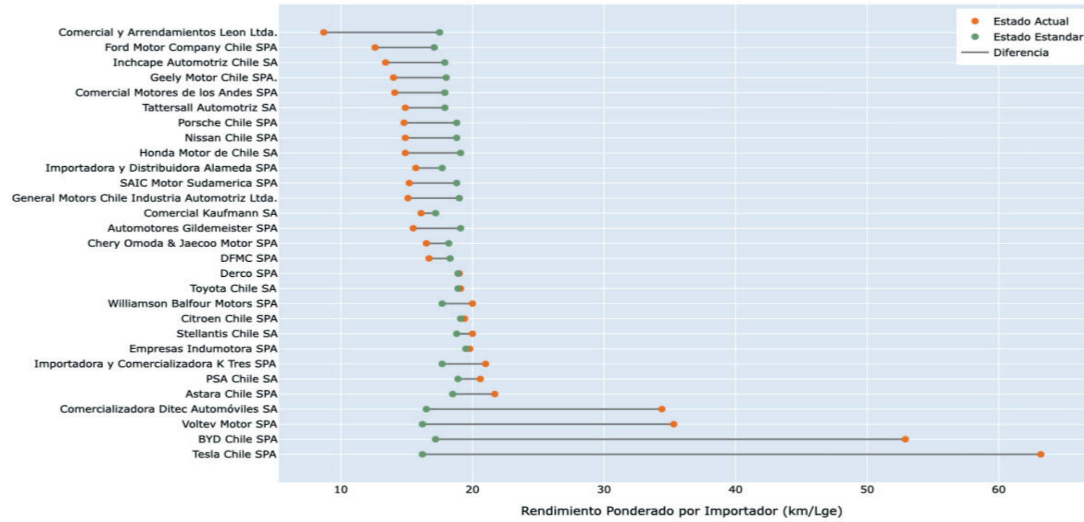


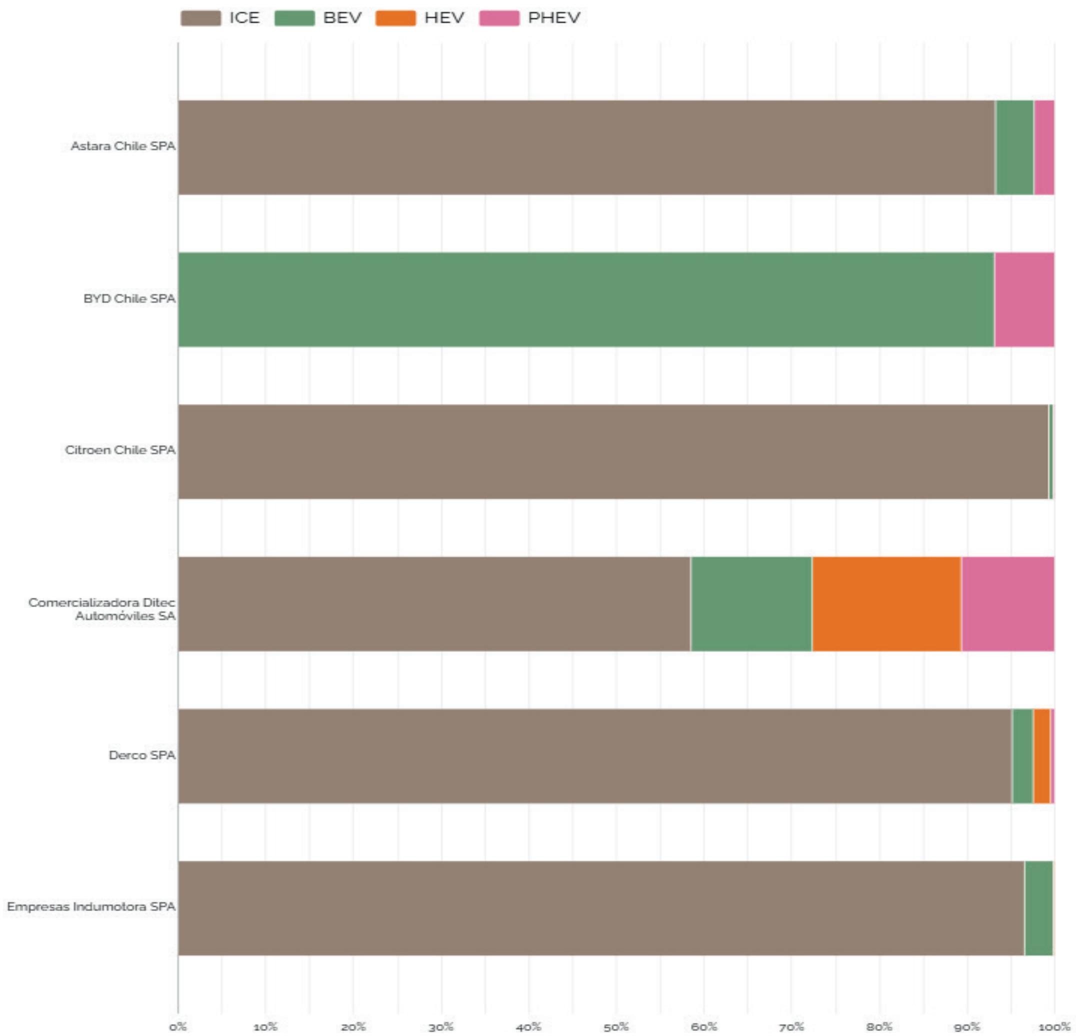
Figure 33. Corporate performance by importer versus its required standard. Author's original image.

Compliance Strategies

Analyzing the 13 compliant importers, it can be observed that they followed two strategies:

- **Focus on sales of plug-ins (BEV and/or PHEV):** carried out by three importers. These can be identified in Figure 34 below thanks to the large percentage of BEV sales, in green. The case is awarded to BYD Chile SPA, Tesla Chile SPA and Voltev Motor SPA, who concentrated their sales on zero-emission vehicles and managed to exceed the standard without inconvenience.
- **Focus on internal combustion sales:** carried out by ten importers. Anyway, within this group there are different approaches. Some companies, such as Astara Chile SPA, Ditec SA, Derco SPA, and Williamson Balfour Motors SPA, complemented their sales of ICE vehicles with certain BEV and PHEV models, taking advantage of the triple sales factor applied to these types of vehicles. Other importers, such as Citroen, PSA Chile and Stellantis Chile SA privileged the sale of ice with good performance, accompanied by a low amount of BEB and/or PHEV sales, this being sufficient to meet their respective annual efficiency requirements. Finally, in the case of Toyota Chile SPA, the sale of HEV vehicles was prioritized. These vehicles offer better performance compared to their ICE counterparts, enabling compliance with the regulations solely through the

sale of low-emission vehicles.



Author's original image.

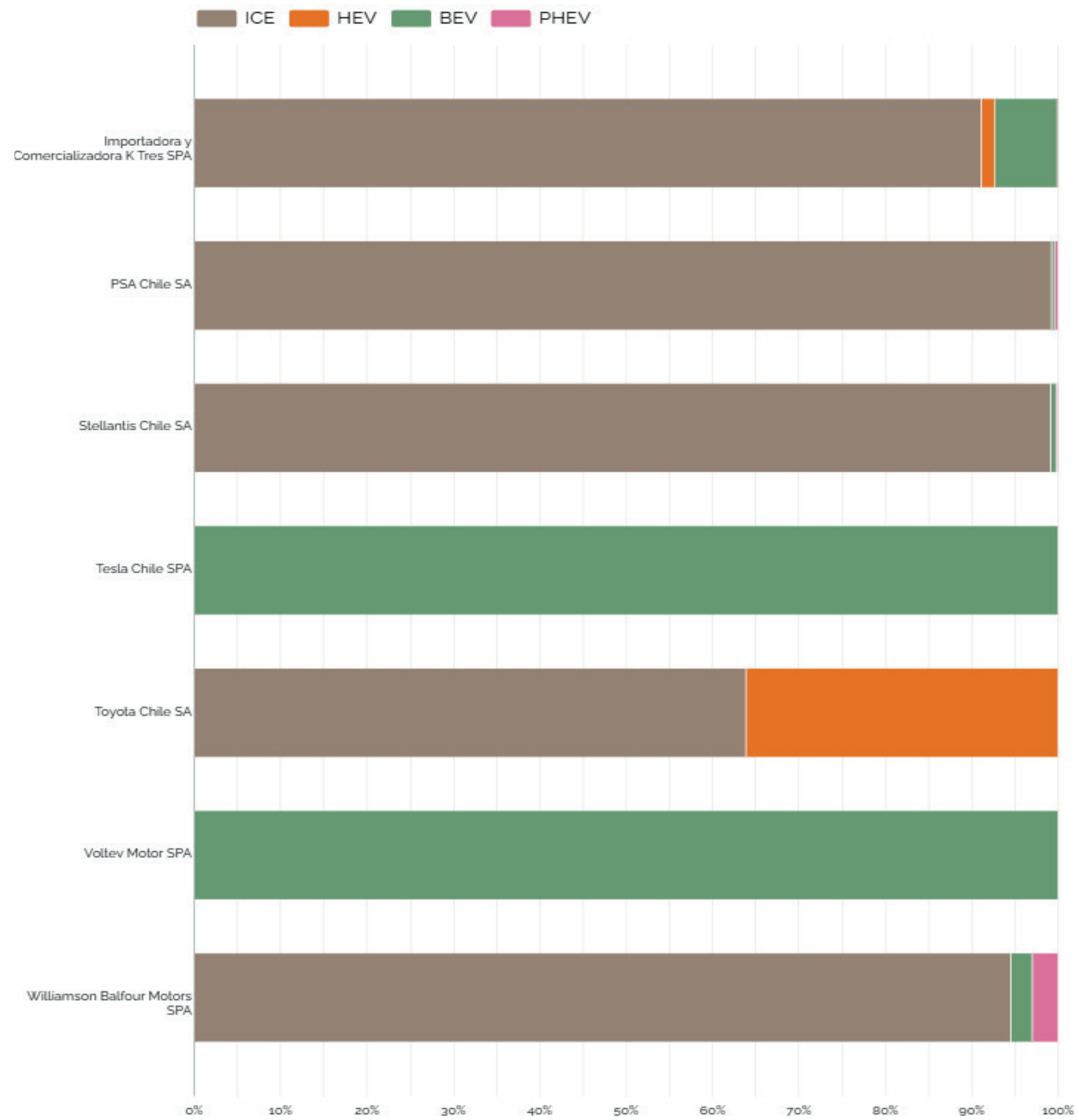


Figure 34. *Percentage of sales by type of propulsion for each compliant importer.* Author's original image.

Results

Energy Efficiency

Figure 35 below shows that once the implementation of the standards began, the average performance of the approved LVs increased by 29%. This represents a huge leap, considering that over ten years, between 2013 and 2023, fuel efficiency increased by 3.8 km/lge, while in less than a year it improved by 5.2 km/lge].

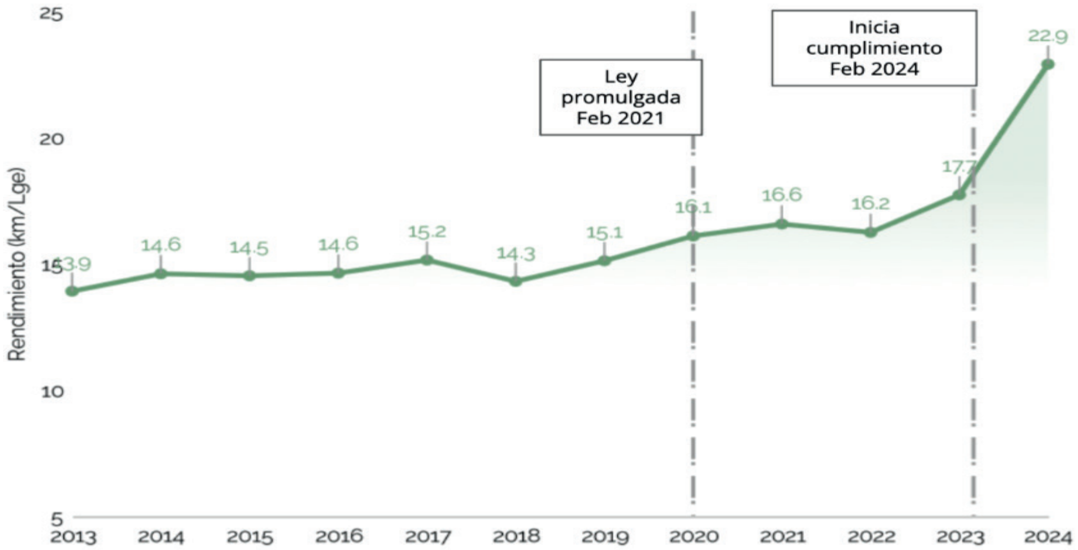


Figure 35. Average performance (km/Lge) of the approved LVs per year
Author's original image.

CO_2 emissions

The CO_2 emissions [g/km] of the approved LVs decreased by 14% in 2024 compared to 2023. This achievement is almost entirely due to plug-in vehicles, as ICE and HEV vehicles showed no significant change.

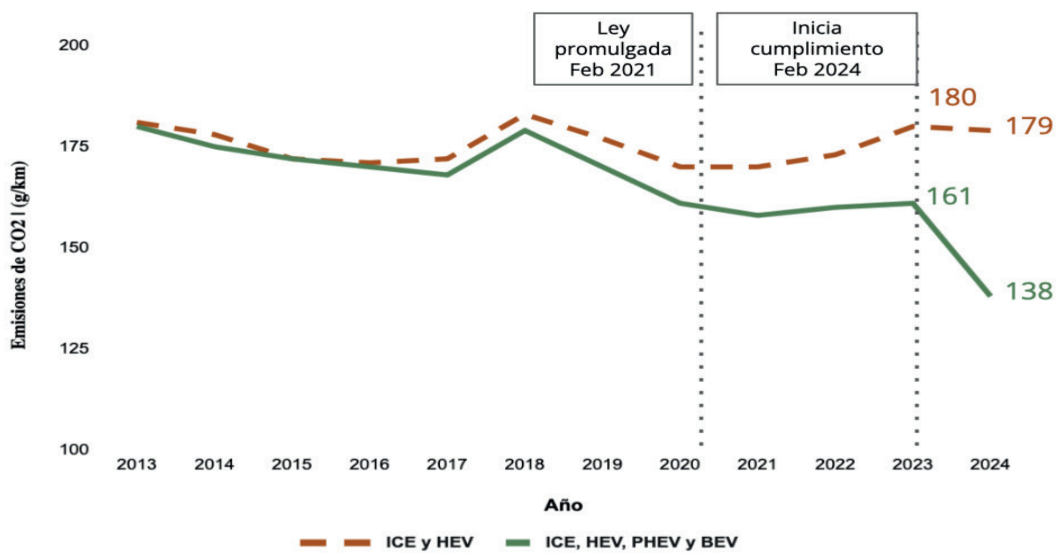


Figure 36. Average CO2 emissions (g/km) of the approved LVs per year, of polluting technologies and all. Author's original image.

Vehicle Supply

In 2024, one in four of the models marketed were plug-in. A fourfold increase compared to 2022.

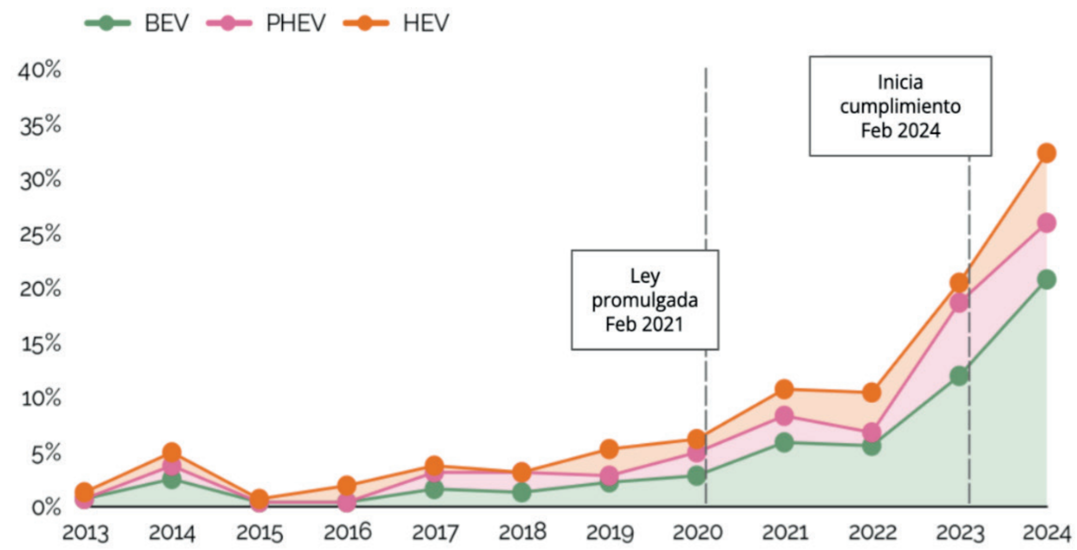


Figure 37. Percentage of number of models approved by propulsion category and year.
Author's original image.

Vehicle Sales

Sales of plug-in electric vehicles (BEVs and PHEVs) increased 2.4 times in the first year of implementation compared to 2023. In addition, considering that as of June 2025, plug-in vehicles represent 2.9% of sales, this implies an increase of 4.3 times compared to 0.67% recorded in 2023.

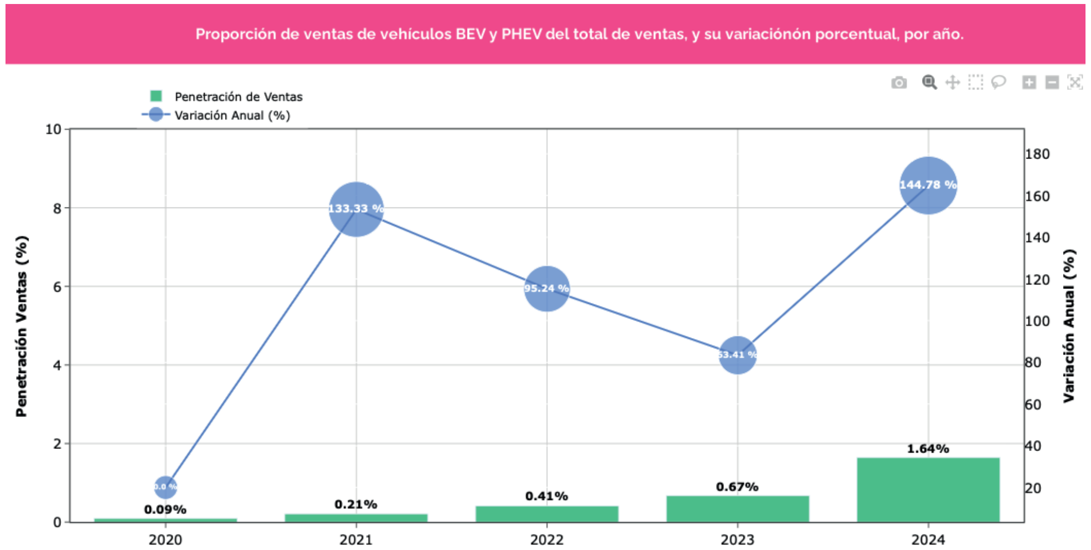


Figure 38. Share of BEV and PHEV vehicle sales as a percentage of total sales, and their yearly percentage change. Author's original image.

Current and upcoming challenges

Implementation of Standards for Medium-Duty Vehicles

Law 21.305 established a period of three years for the definition of MV standards, which are vehicles whose PBV is between 2,700 and 3,860 [kg]. These were met in February 2024, with the MoE's publication occurring in April 2024. In this case, the year 2020 was established as a baseline, which has been criticized by industry since it is argued that the context has changed in recent times and such values are no longer representative. In response, the MoE published a second technical standards report in July 2025. The most serious issue, from a public policy and environmental perspective, is that its official start has been delayed from April 2026 to April 2028..

Design of Standards for Heavy-Duty Vehicles

The correct definition of energy efficiency standards is the current challenge for the VP segment, which are vehicles whose PBV is greater than 3,860 [kg]. This is due to the segment having diverse operations, weights, and performance levels, as well as being key to national logistics, especially in an export-oriented country where goods are transported by trucks to seaports.

On the other hand, the implementation and success of standards regulation for LDVs and HDVs has been possible thanks to the 3CV of the Ministry of Transport and Telecommunications, which operates a laboratory capable of measuring vehicle energy performance and emissions. However, this is not the case for VP, and crafting a suitable site means a high investment.

Lastly, there is resistance from the industry, arguing that this segment, unlike LDVs and MDVs, self-regulates its energy efficiency. This observation stems from the fact that transport companies compete on price in freight contracts, and that the winner, in theory, should achieve the highest energy efficiency. This would allow to decrease the value of the contract, considering that the cost of fuel is the main cost of operation for the case of the VP.

Next Steps for Light-Duty Vehicles

The validity of the performance standard for light vehicles is in its first stage, so a greater demand is expected in the following sections: from 2027 and from 2030. It is with this in mind that it is proposed to maintain the monitoring of vehicle efficiency, contributing to correct regulatory compliance in the years to come. Greater compliance is expected in the short term, once non-compliant importers know the value of the fine to be paid.

In addition, in the medium term, the PHEV sales factor for compliance with the standard should decrease. It has been proven that PHEV users support the use mostly in the internal combustion section of their vehicles, so the energy efficiency of these is lower than theoretically proposed.

Tables for generating graphs

Table 18. Vehicle Performance Chart

Year	Chile	EU	UK	US
2000	-	13,6 [km/lge]	-	11,4 [km/lge]
2001	-	13,7 [km/lge]	13,1 [km/lge]	11,6 [km/lge]
2002	-	14,0 [km/lge]	13,4 [km/lge]	11,6 [km/lge]
2003	-	14,1 [km/lge]	13,5 [km/lge]	11,9 [km/lge]
2004	-	14,3 [km/lge]	13,6 [km/lge]	11,8 [km/lge]
2005	11,1 [km/lge]	14,4 [km/lge]	13,8 [km/lge]	12,2 [km/lge]
2006	11,3 [km/lge]	14,5 [km/lge]	14,0 [km/lge]	12,1 [km/lge]
2007	11,6 [km/lge]	14,7 [km/lge]	14,2 [km/lge]	12,6 [km/lge]
2008	11,7 [km/lge]	15,2 [km/lge]	14,8 [km/lge]	12,7 [km/lge]
2009	11,7 [km/lge]	16,0 [km/lge]	15,5 [km/lge]	13,3 [km/lge]
2010	12,0 [km/lge]	16,7 [km/lge]	16,0 [km/lge]	13,7 [km/lge]
2011	13,2 [km/lge]	16,9 [km/lge]	16,7 [km/lge]	13,4 [km/lge]
2012	13,4 [km/lge]	17,6 [km/lge]	17,4 [km/lge]	14,4 [km/lge]
2013	14,0 [km/lge]	18,4 [km/lge]	18,1 [km/lge]	15,1 [km/lge]
2014	14,0 [km/lge]	19,0 [km/lge]	18,7 [km/lge]	15,4 [km/lge]
2015	14,2 [km/lge]	19,5 [km/lge]	19,3 [km/lge]	15,8 [km/lge]
2016	14,5 [km/lge]	19,5 [km/lge]	19,5 [km/lge]	15,9 [km/lge]
2017	14,5 [km/lge]	19,5 [km/lge]	19,3 [km/lge]	16,8 [km/lge]
2018	14,5 [km/lge]	19,0 [km/lge]	18,4 [km/lge]	18,0 [km/lge]
2019	14,5 [km/lge]	19,2 [km/lge]	18,3 [km/lge]	18,1 [km/lge]
2020	14,9 [km/lge]	21,4 [km/lge]	20,5 [km/lge]	19,0 [km/lge]
2021	14,7 [km/lge]	24,3 [km/lge]	24,6 [km/lge]	20,9 [km/lge]
2022	14,8 [km/lge]	25,7 [km/lge]	25,4 [km/lge]	21,4 [km/lge]
2023	14,9 [km/lge]	26,3 [km/lge]	26,0 [km/lge]	26,0 [km/lge]

Table 19. Performance Chart by Importer

Importer	Target Performance	Performance
Comercial y Arrendamientos Leon LTDA	17,5 [km/lge]	8,7 [km/lge]
Ford Motor Company Chile SPA	17,1 [km/lge]	12,6 [km/lge]
Inchcape Automotriz Chile SA	17,9 [km/lge]	13,4 [km/lge]
Geely Motor Chile SPA	18,0 [km/lge]	14,0 [km/lge]
Comercial Motores de Los Andes SPA	17,9 [km/lge]	14,1 [km/lge]
Tattersall Automotriz SA	17,9 [km/lge]	14,9 [km/lge]
Porsche Chile SPA	18,8 [km/lge]	14,8 [km/lge]
Nissan Chile SPA	18,8 [km/lge]	14,9 [km/lge]
Honda Motor de Chile SA	19,1 [km/lge]	14,9 [km/lge]
Importadora y Distribuidora Alameda SPA	17,7 [km/lge]	15,7 [km/lge]
SAIC Motor Sudamérica SPA	18,8 [km/lge]	15,2 [km/lge]
General Motors Chile Industria Automotriz LTDA	19,0 [km/lge]	15,1 [km/lge]
Comercial Kaufmann SA	17,2 [km/lge]	16,1 [km/lge]
Automotores Gildemeister SPA	19,1 [km/lge]	15,5 [km/lge]
Chery Omoda & Jaecoo Motor SPA	18,2 [km/lge]	16,5 [km/lge]

Importer	Target Performance	Performance
DFMC SPA	18,3 [km/lge]	16,7 [km/lge]
Derco SPA	18,9 [km/lge]	19,0 [km/lge]
Toyota Chile SA	18,9 [km/lge]	19,1 [km/lge]
Williamson Balfour Motors SPA	17,7 [km/lge]	20,0 [km/lge]
Citroen Chile SPA	19,1 [km/lge]	19,4 [km/lge]
Stellantis Chile SA	18,8 [km/lge]	20,0 [km/lge]
Empresas Indumotora SPA	19,5 [km/lge]	19,8 [km/lge]
Importadora y Comercializadora K Tres SPA	17,7 [km/lge]	21 [km/lge]
PSA Chile SA	18,9 [km/lge]	20,6 [km/lge]
Astara Chile SPA	18,5 [km/lge]	21,7 [km/lge]
Comercializadora Ditec Automóviles SA	16,5 [km/lge]	34,4 [km/lge]
Voltev Motor SPA	16,2 [km/lge]	35,3 [km/lge]
BYD Chile SPA	17,2 [km/lge]	52,9 [km/lge]
Tesla Chile SPA	16,2 [km/lge]	63,2 [km/lge]

Table 20. Sales Percentage Chart by Vehicle Type

Importer	Category	Sales
Astara Chile SPA	BEV	724
Astara Chile SPA	ICE	15.347
Astara Chile SPA	PHEV	389
BYD Chile SPA	BEV	27
BYD Chile SPA	PHEV	2

Importer	Category	Sales
Citroen Chile SPA	BEV	27
Citroen Chile SPA	ICE	5.425
Citroen Chile SPA	PHEV	10
Comercializadora Ditec Automóviles SA	ICE	148
Comercializadora Ditec Automóviles SA	BEV	35
Comercializadora Ditec Automóviles SA	HEV	43
Comercializadora Ditec Automóviles SA	PHEV	27
Derco SPA	BEV	1.132
Derco SPA	PHEV	226
Derco SPA	HEV	939
Derco SPA	ICE	44.837
Empresas Indumotora SPA	BEV	467
Empresas Indumotora SPA	ICE	13.726
Empresas Indumotora SPA	HEV	25
Importadora y Comercializadora K Tres SPA	ICE	2.240
Importadora y Comercializadora K Tres SPA	PHEV	2
Importadora y Comercializadora K Tres SPA	HEV	39
Importadora y Comercializadora K Tres SPA	BEV	178
PSA Chile SA	ICE	6.293
PSA Chile SA	PHEV	26
PSA Chile SA	BEV	22
Stellantis Chile SA	PHEV	17

Importer	Category	Sales
Stellantis Chile SA	BEV	49
Stellantis Chile SA	ICE	7,612
Tesla Chile SPA	BEV	936
Toyota Chile SA	ICE	7.377
Toyota Chile SA	HEV	4.175
Voltev Motor SPA	BEV	1
Williamson Balfour Motors SPA	BEV	14
Williamson Balfour Motors SPA	PHEV	17
Williamson Balfour Motors SPA	ICE	535

Table 21 Average Performance Chart of Approved LCVs by Year in Chile

Year	Average LCY Performance
2013	13,9 [km/lge]
2014	14,6 [km/lge]
2015	14,5 [km/lge]
2016	14,6 [km/lge]
2017	15,2 [km/lge]
2018	14,3 [km/lge]
2019	15,1 [km/lge]
2020	16,1 [km/lge]
2021	16,6 [km/lge]
2022	16,2 [km/lge]
2023	17,7 [km/lge]
2024	22,9 [km/lge]

Table 22. Average CO_2 Emissions Chart of Approved LCVs by Year in Chile

Year	Ice, HEV, PHEV and BEV EMISSIONS	Ice and PHEV emissions
2013	180 [gCO_2/km]	181 [gCO_2/km]
2014	175 [gCO_2/km]	178 [gCO_2/km]
2015	172 [gCO_2/km]	172 [gCO_2/km]
2016	170 [gCO_2/km]	171 [gCO_2/km]
2017	168 [gCO_2/km]	172 [gCO_2/km]
2018	179 [gCO_2/km]	183 [gCO_2/km]
2019	170 [gCO_2/km]	177 [gCO_2/km]
2020	161 [gCO_2/km]	170 [gCO_2/km]
2021	158 [gCO_2/km]	170 [gCO_2/km]
2022	160 [gCO_2/km]	173 [gCO_2/km]
2023	161 [gCO_2/km]	180 [gCO_2/km]
2024	138 [gCO_2/km]	179 [gCO_2/km]

Table 23. Model Percentage Chart by Vehicle Type

Year	BEV Porcentage	PHEV Porcentage	HEV Porcentage
2013	0,61%	0,00%	0,61%
2014	2,43%	1,22%	1,22%
2015	0,30%	0,00%	0,30%
2016	0,30%	0,00%	1,52%
2017	1,52%	1,52%	0,61%
2018	1,22%	1,82%	0,00%
2019	2,13%	0,61%	2,43%
2020	2,74%	2,14%	1,22%
2021	5,78%	2,43%	2,43%
2022	5,47%	1,22%	3,65%
2023	11,85%	6,69%	1,82%
2024	20,67%	5,17%	6,38%

Table 24. Chart of Change in Sales of Zero-Emission Vehicles by Year in Chile

Year	Sales share	Annual Variation
2020	0,09%	0,00%
2021	0,21%	133,33%
2022	0,41%	95,24%
2023	0,67%	63,41%
2024	1,64%	144,78%

Author: Climatesworks

Supply-Side Regulations (SSR) to Accelerate Electric Vehicle Adoption in Latin America

One of the fundamental mechanisms to steer the vehicle market towards greater energy efficiency is the application of Supply Side Regulations (SSR). This chapter, prepared by the International Council on Clean Transportation (ICCT), sets out two of the most widespread instruments in this area: 1) electric vehicle sales requirements, and 2) minimum performance standards that require new vehicles to meet, on average, criteria for energy efficiency or CO_2 emissions. In Latin America, the ICCT, together with organizations such as the Climate Works Foundation, GIZ and UNEP, has provided technical support to governments for the adoption of regulations of this type.

In Chile, in particular, the energy efficiency standard for light-duty vehicles was implemented. The previous chapter, developed by the Center for Sustainable Mobility, presents a summary of the regulatory design and the results obtained with Chilean regulations.

To achieve an agile transition to electric vehicles (EVs), it is essential to implement a combination of policies that guarantee their wide availability, affordability, and ease of both acquisition and everyday use. In the early stages of this transition, Latin American governments have mainly resorted to fiscal policies that incentivize the purchase of electric vehicles. In addition, some countries have created strategies that promote charging infrastructure and have implemented industrial policies aimed at promoting the development of local EV supply chains and manufacturing.

Major EV markets globally have driven the transition to electric vehicles through Supply Side Regulations (SSR), which set requirements for the types of vehicles that can be sold in a country to encourage the shift to more efficient and electric vehicles. These regulations are presented mainly in two forms: on the one hand, establishing requirements for the sale of EVs, which require manufacturers to sell a certain percentage of electric vehicles each year, on the other hand, through performance-based standards, which require new vehicles to meet average targets for energy efficiency and reduction of CO_2 emissions. In both cases, manufacturers who fail to meet the goals of these regulations will have to pay a fine or bear other penalties. These policies make the transition to electric vehicles a fundamental part of the car companies' business model and offer clarity regarding the pace of this transition, allowing all parties involved to coordinate their plans jointly.

This chapter summarizes the key components of the two main types of SRH, including which governments have adopted them, providing examples of their benefits and outlining the steps to adopt them as part of the transition to electric mobility. Although this chapter will focus on automobiles, which account for most fuel consumption and emissions, these types of policies can also be applied to other types of vehicles, such as trucks, buses, and motorcycles.

Types of SSR regulations

Supply-side regulations for electric vehicles can take two basic forms: i) setting requirements for the sale of electric vehicles and ii) on performance-based standards. Both have proven effective in increasing EV sales, reducing emissions, and supporting the growth of EV supply chains. Although, they differ in the way manufacturers comply with them and in the complexity involved in their design and application. These two measures can also be applied in combination - as is the case in China and the United Kingdom - although this increases the complexity of the policy

Performance-Based Standards

Performance-based standards require manufacturers to sell more efficient and less polluting vehicles, specifying the objectives that each car manufacturer must meet. These can be measured in terms of emissions (grams ofCO2 per kilometer), fuel efficiency (kilometers per liter [km/L]) or fuel consumption (liters per 100 kilometers [L/100km]). Although metrics vary, they all have similar effects on the vehicle market becauseCO2 emissions are directly related to the amount of fuel consumed, and standards can be directly compared even if they have different metrics.

This type of standard is technologically neutral, allowing manufacturers to use a combination of strategies to meet it: they can increase the efficiency of internal combustion engines (ICEs), sellhybrid vehicles, sell electric vehicles, or apply a combination of strategies. However, since electric vehicles are much more efficient than hybrids and do not generate tailpipe emissions, they are an attractive option to meet the standard, and even as an option that could be employed if the standards are strict enough.

It is important to note that these objectives are not requirements for all vehicles sold, but for the global average of each company's fleet. This means that companies can sell a variety of vehicles to suit consumer preferences. Thus, less efficient vehicles, such as SUVs and gasoline pickup trucks without advanced technologies, can be compensated with more efficient options, such as electric vehicles.

In addition, it should be borne in mind that performance-based standards have a long history. These have been applied from the 70s to the 2000s, even before modern electric vehicles existed, dozens of countries around the world regulated the fuel consumption of vehicles to achieve environmental, economic and energy safety objectives. The current availability of electric vehicles has allowed governments to set stricter standards approaching 0 g CO2/km. Figure 40 shows all the standards adopted based on performance (dashed line) and proposals (dotted line) for cars worldwide.

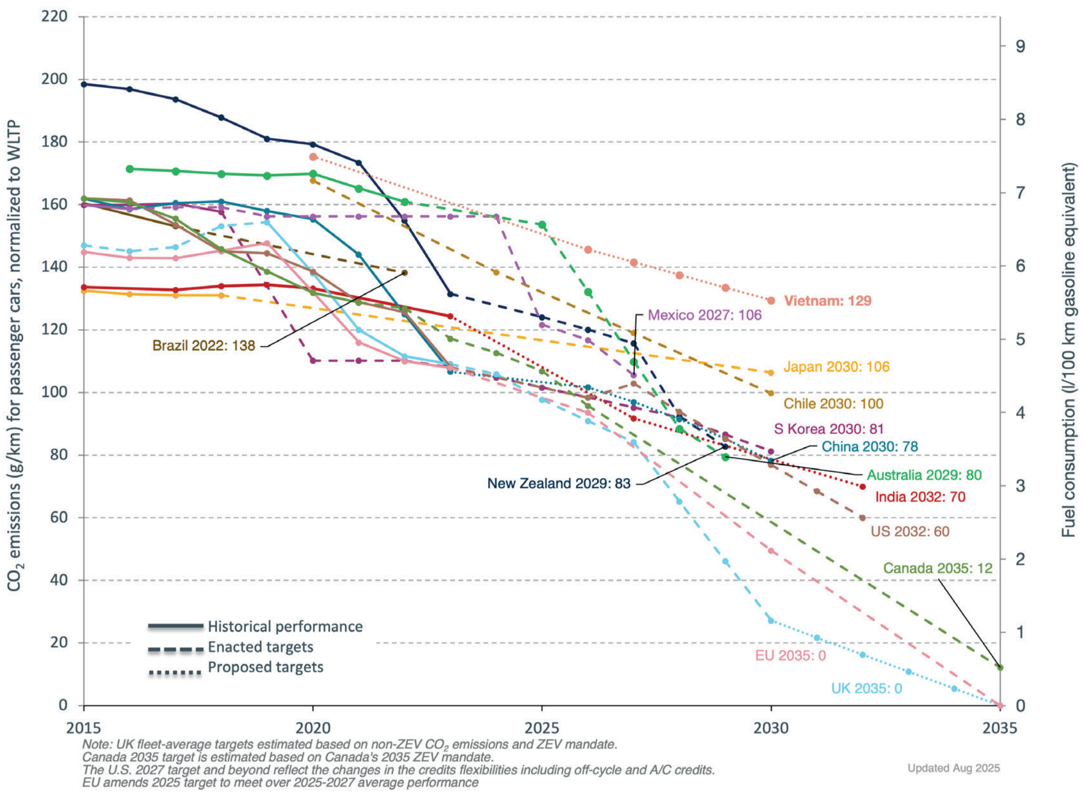


Figure 40. Comparison of performance-based standards for cars, standardized according to the World Harmonized Light Vehicle Test Procedure (WLTP).

Requirements for the sale of electric vehicles

Electric vehicle sales requirements set targets for the percentage of a manufacturer's new vehicle sales that must be electric in a given year. Zero-emission vehicle (ZEV) sales requirements are generally applied through a credit system. Each year, manufacturers have a credit requirement proportional to their total vehicle sales volume. Manufacturers obtain credits mainly through the sale of electric vehicles; more efficient conventional vehicles, such as conventional (non-plug-in) hybrids, are not taken into account because all their energy comes from the combustion of liquid fuels.[89] In most cases, these credits can be negotiated between manufacturers or, if they exceed the electric vehicle sales target, saved for use in future years.

89 *In some regulations, PHEVs may earn partial credits or count toward a limited portion of the electric vehicle requirement. In California and Canada, for example, PHEVs can account for up to 20% of the electric vehicle requirement each year.*

Electric vehicle sales requirements are a more recent type of policy than performance-based standards, but they have been a crucial tool in developing the electric vehicle market in leading markets such as California, China and the United Kingdom. Figure 41 compares the sales requirements of electric vehicles adopted (solid line), proposed (long lines) or adopted but under litigation (short lines) around the world. China does not appear because its annual credit targets are more complex to link to zero-emission vehicle (ZEV) sales projections.

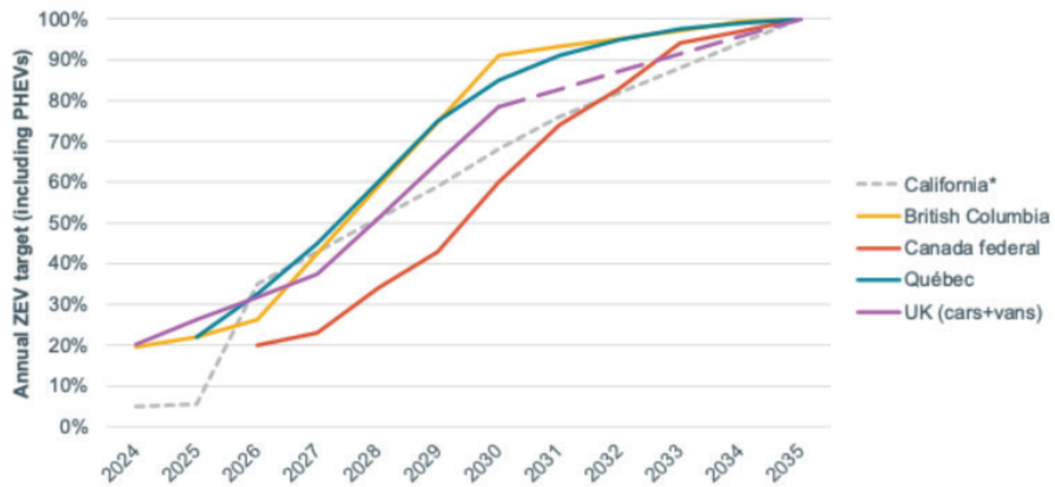


Figure 41 Comparison of Zero-Emission Vehicle Sales Requirements in California, Canada and the United Kingdom

An advantage of electric vehicle sales requirements is that they are much simpler to design, monitor and implement compared to fuel consumption standards. To design an electric vehicle sales requirement, the government does not need to consider the cost-effectiveness and feasibility of incremental improvements in the efficiency of internal combustion engines. To monitor compliance, regulators only need to know the number of zero-emission vehicles a manufacturer sells each year, rather than reviewing each vehicle's technical specifications. This makes these regulations especially attractive for sub-national jurisdictions that have historically lacked standards on light-duty vehicle emissions, as well as for heavy-duty vehicles, which are more difficult to test.

Comparison of Supply-Side Regulation Options

The following table summarizes the main characteristics of the standards based on the performance and sales requirements of zero-emission vehicles (ZEV), allowing to identify their implementation, compliance mechanisms, the degree of certainty required and provided to the sector, as well as the regions in the world where these regulatory approaches are applied.

Tabla 25. Key Characteristics of Zero-Emission Vehicle (ZEV) Performance-Based Standards and Sales Requirements

	Performance-Based Standards	ZEV Sales Requirement	Combination
Metric	Average fuel consumption (e.g. L/100 km) or CO2 emissions (g CO2/km) of new vehicles sold	Percentage of new vehicles sold that are ZEV	Percentage of new vehicles sold that are ZEV, plus fuel consumption or CO2 standards for non-Zev vehicles or for the entire fleet
Ways to comply	More efficient internal combustion engine vehicles, hybrids and increased ZEV SALES	Increase in ZEV's sales quota, possibly including a limited number of Plug-in Hybrid Electric Vehicles (PHEVs)	Increased sales of ZEV and more efficient ice vehicles (including hybrids)..
Certification Required	Light-Duty Vehicles: Testing and Certification of Each Model Variant Heavy Duty Vehicles: Combining Vehicle/Component Testing and Simulation	Powertrain only; pHEVs may require emission certification or autonomy by model	Light-Duty Vehicles: Testing and Certification of Each Model Variant Heavy Duty Vehicles: Combining Vehicle/ Component Testing and Simulation
Normally implemented by	National governments	National or state/regional governments	National governments
Certainty for ZEV Supply Chains and Infrastructure	Moderate	High	High
Certainty of Meeting ZEV Targets	Moderate	High	High
Encourages improvements in the efficiency of vehicles with internal combustion engines (ICEs)	Yes	No	Yes
May allow interchange between manufacturers	Yes	Yes	Yes
Administrative Procedures	Moderate (Cars) to High (Heavy-Duty Vehicles)	Low	High
Regions with policies in place for passenger cars	Australia, Brazil, Canada, Chile, European Union, India, Japan, Mexico, New Zealand, South Korea, United States	California and 17 other U.S. states. USA, Canada, National Capital Region of India	China, United Kingdom
Regions with policies in place for heavy-duty vehicles	China, India, Japan, European Union, United States	California and 10 other U.S. states. USA, European Union (transit buses)	

Source: Own elaboration

Key elements to consider for the design of SRH

For both electric vehicle sales requirements and performance-based standards, there are several elements that must be included in an SSR.

1. Metas. Establecer los objetivos para las SSR, idealmente con periodicidad anual para garantizar un progreso constante, en lugar de a intervalos de tres o cinco años. Es importante que estos objetivos estén alineados con los objetivos a largo plazo en materia de vehículos eléctricos y descarbonización, incluidas las Contribuciones Determinadas a Nivel Nacional (NDCs, por sus siglas en inglés), tanto de los marcos regulatorios como de las políticas públicas de los países en donde se formulen e implementen.

1. Goals. Set goals for SRH, ideally on an annual basis to ensure steady progress, rather than at three- or five-year intervals. It is important that these objectives are aligned with the long-term objectives of electric vehicles and decarbonization, including Nationally Determined Contributions (NDCs), both in the regulatory frameworks and in the public policies of the countries where they are formulated and implemented.

In the case of performance-based standards, it is important that the objectives are sufficiently strict to drive the adoption of electric vehicles. In addition, these regulations should encourage incremental efficiency gains among non-electric vehicles, which can increase annually by around 3%[90] .

The choice of test cycle also influences the degree to which fuel savings manifest themselves in the real world. In this sense, the design of objectives based on the World Harmonized Light Vehicle Test Procedure (WLTP) or the FTP-75, developed by the United States Environmental Protection Agency (EPA), will probably achieve greater benefits in real conditions than the obsolete New European Driving Cycle (NEDC).[91]

2. Credit system. Standards are usually implemented through a credit system, under which manufacturers accumulate credits based on the types of vehicles they sell and must hold a certain number of credits at the end of each compliance period (for example, calendar year or model year).

For electric vehicle sales requirements, most standards give a credit for each electric vehicle sold. Some systems grant partial credits to plug-in hybrid electric vehicles (PHEVs) and others grant credits according to a progressive scale based on the vehicle's autonomy or other parameters.

In the case of performance-based standards, credits are granted based on the vehicle's emissions or fuel consumption. Therefore, the goal of many systems is to stay below a certain level of credit. Some performance-based standards offer "super credits" or multipliers to electric vehicles in the early stages in which SRH regulates the market and in which electric vehicles are counted several times in the average number of units sold in the fleet to make their commercialization more attractive. This can accelerate electric vehicle sales in the early stages of the market for these technologies but will result in lower emissions reductions for the same target. For this reason, most performance-based standards have gradually eliminated super credits as the electric vehicle market has developed.

90 Hall, D., Posada, F., Syahputri, J., Miller, J., & Yang, Z. (2024). The role of supply-side regulations in meeting Indonesia's 2030 electric vehicle target. International Council on Clean Transportation. https://theicct.org/publication/role-of-supply-side-regulations-in-meeting-indonesias-2030-ev-target-jul24/

91 Kühlwein, J., German, J., & Bandivadekar, A. (2014). Development of test cycle conversion factors among worldwide light-duty vehicle CO2 emission standards. International Council on Clean Transportation. https://theicct.org/publication/development-of-test-cycle-conversion-factors-among-worldwide-light-duty-vehicle-co2-emission-standards/; Dornoff, J., Valverde Morales, V., & Tietge, U. (2024). On the way to 'real-world' CO2 values? The European passenger car market after 5 years of WLTP. International Council on Clean Transportation. https://theicct.org/publication/real-world-co2-emission-values-vehicles-europe-jan24/

3. Credit trading. Most SSRs allow credits to be traded between manufacturers at a market-determined price. This offers an alternative way to comply with the regulations and avoid sanctions on manufacturers by the regulatory body responsible, so that they have more time to move to electric vehicles; these transactions can also be an important source of income for manufacturers that reduce their emissions above the minimum required.

4. Monitoring and compliance. For SRH to be successful, it is necessary to track manufacturers' sales every year. This data should be published to promote transparency and give manufacturers the opportunity to correct any errors. In many cases, data can be obtained through existing channels, such as vehicle registration records and tax records.

Electric vehicle sales requirements are easier to manage because less information is needed (vehicle propulsion system and potential electric range only). Performance-based standards require emission and fuel consumption tests for each model variant. In the case of heavy vehicles, governments sometimes resort to simulation due to the greater number of variants and the high cost of testing large vehicles.

5. Penalties. For SRHs to build confidence in the growth of the ZEV market, they must be binding. In almost all SRH globally, this applies through fines imposed on manufacturers who fail to meet their targets, with amounts proportional to the number of vehicles sold and the difference between the manufacturer's goal and performance.

The optimal level of a penalty is determined by several factors. First, it should take into account the cost of the additional impact on climate and air pollution resulting from the sale of more polluting internal combustion engine vehicles. Second, the penalties must be high enough so that manufacturers are not tempted to simply pay the fines, rather than make the necessary investments to comply with the regulations. Finally, if a regulation allows the transaction of credits, the fine acts as a ceiling for the price at which credits can be negotiated, influencing how much manufacturers are incentivized to invest in electric vehicles and lead the transition.

SSR Benefits

By setting requirements to sell cleaner vehicles or face penalties, SRH encourages manufacturers to compete to switch to electric vehicles and reduces the burden on governments to offer incentives and other demand-oriented policies. In addition, SRH has a proven track record of environmental and economic benefits. Among them are:

1. Electric vehicle sales and model availability increase. The world's 15 largest electric vehicle markets in 2023 had electric vehicle sales requirements, fuel consumption or CO_2 standards, or a combination of both. Introducing or strengthening SRH has led to a dramatic growth in electric vehicle sales share in markets in the European Union, New Zealand and the United Kingdom. SRH has also motivated manufacturers to offer more electric vehicle options, increasing consumer choice. In 2023, California and other states that adopted zero-emission vehicle sales requirements recorded a 30% increase in the availability of electric or plug-in hybrid models compared to states that did not have such requirements, generating more competition and options for drivers (Bui and Slowik, 2024). Following the introduction of ZEV regulation in the UK, many new models became available, affordable options aimed at cost-conscious consumers of these vehicles.[92]

2. Promote investments in electric vehicle supply chains. SRH encourages investments in the zero-emission vehicle supply chain. Vehicle manufacturers are likely to invest in the creation or expansion of electric vehicle manufacturing in markets where demand is expected to grow due to such regulations. In Canada, the European Union, the United Kingdom and the United States, manufacturers announced investments of billions of dollars in the manufacture of electric vehicles and batteries just before or after the entry into force of the new rules. For example, shortly before the ZEV regulations came into effect in the United Kingdom, the Tata Group announced that it had chosen the UK to invest £4 billion in a battery gigafactory, aimed at producing batteries to meet the domestic demand for Jaguar and Land Rover vehicles, as well as for export.[93] More broadly, vehicle manufacturers have made greater commitments to sell electric vehicles in regions with strong SSRs, such as Europe. Since most electric vehicles are produced in the regions in which they are sold, this could lead to local manufacturing growth.[94] In addition, credit trading can provide an additional boost to leading electric vehicle companies; the sale of SSR credits was crucial to Tesla's survival and growth.[95]

3. Encourage investment in charging infrastructure. The certainty in electric vehicle sales promoted by SSRs, electric vehicle sales requirements, gives the private sector confidence that the charging infrastructure will be used and, therefore, that they can invest in building a network with less government support. For example, ChargeUK, a recharging industry trade association in the United Kingdom, stated that its partner companies have committed to invest £6 billion in public recharging infrastructure through 2030, based on the trust provided by the ZEV mandate, which would not have happened if there were only non-binding targets.[96]

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92 *Palmer, R. (2024). The ZEV mandate fuels UK's EV boom. Transport & Environment. https://www.transportenvironment.org/te-united-kingdom/articles/the-zev-mandate-fuels-the-uks-ev-boom*

93 *Joshi, P., & Kavanagh, T. (2023, July 19). India's Tata to build battery gigafactory in UK: Update. Argus Media. https://www.argusmedia.com/en/news-and-insights/latest-market-news/2470619-india-s-tata-to-build-battery-gigafactory-in-uk-update*

94 *Fadhil, I. (2023, October 20). Which automakers are keeping the ZEV momentum strong? ICCT Staff Blog. https://theicct.org/automakers-are-keeping-the-zev-momentum-strong-oct23/; Fadhil, I., & Shen, C. (2025). Global electric vehicle market monitor for light-duty vehicles in key markets, 2024. International Council on Clean Transportation. https://theicct.org/publication/global-ev-market-monitor-for-ldv-in-key-markets-2024-jun25/*

95 *https://eprinc.org/wp-content/uploads/2024/11/Deck-Chart2024-46-TeslaAutomotiveCreditsAndGrossProfit.pdf*

96 *Read, V. (2024, October 4). ChargeUK letter to the Rt Honorable Rachel Reeves. https://www.linkedin.com/posts/chargeuk_chargeuk-letter-to-the-rt-hon-rachel-reeves-activity-7248018751059587072-Az-X*

Interviews

Introduction

Within the framework of this White Paper on Sustainable Mobility, the Latin American Energy Organization (OLADE) recognizes that the challenges associated with mobility in the region do not support universal solutions or homogeneous approaches. On the contrary, they require alternatives designed and adapted to the social, cultural, economic, geographical and technological particularities of each country and community.

In this regard, this chapter brings together six interviews with key actors in the field of sustainable mobility in Latin America and the Caribbean, including representatives of users, associations, and companies that develop innovative solutions. The objective is to provide a plural and complementary vision that allows identifying trends, challenges and opportunities in the transition towards cleaner, more efficient and equitable transport systems.

The collection of these perspectives was carried out through an interview questionnaire. The responses collected offer a diverse panorama of strategies and experiences, contributing to technical and regional dialogue on the future of sustainable mobility.

In line with the evolving nature of this White Paper, it is expected that in future editions this exercise will be expanded, incorporating new voices and visions from different geographical contexts, productive sectors and technological areas, thus strengthening the collective construction of knowledge for the benefit of OLADE member countries.

Interview Format

Each interview is presented in a question-and-answer outline. The questions are listed consecutively from 1 to 7 and the answers maintain the direct voice of the interviewees, respecting their contributions and experiences.

The interview form was structured around the following seven questions:

1. **Participation in sustainable mobility**
   Sustainable mobility is gaining more prominence in the region. From your experience, or that of your institution, how have you engaged with this topic? What kind of solutions or initiatives have you implemented or promoted?
2. **Motivations, benefits and challenges**
   What do you think have been the main advantages of adopting sustainable mobility solutions? Have you also identified any significant disadvantages or challenges? What factors motivated the shift towards this type of mobility?
3. **Comparison with traditional mobility**
   From your perspective, do you think that sustainable mobility solutions allow you to perform the same activities or functions as those based on traditional technologies (for example, combustion engines)? Why?
4. **Barriers and opportunities for improvement**
   What have been, in your experience, the main barriers to entry for the use or implementation of sustainable mobility solutions, both at the individual, institutional or market level?
5. **Aftermarket Capabilities and Services**
   Currently, do you think that aftermarket services, the availability of spare parts and spare parts are adequate to guarantee the correct development of sustainable mobility? Also, do you think there is enough technical training to ensure the maintenance and repair of these vehicles?
6. **Looking toward the future,**
   what actions do you consider necessary to accelerate the transition towards more sustainable mobility in the region? What role should governments, the private sector, citizens and international organizations play?
7. **Final comment**
   Do you want to share any additional thoughts or messages on this topic?

Gerardo Sastre,
president of the Association of Drivers of Applications (ACUA). Uruguay.

Response N°1

Based on the experience we contributed from the association and in our activity the growth of the use for public transport increased.

Response N°2

The advantages are the fuel savings in the transport activity; and disadvantages, charging points on the public road and battery performance if the day is intense 24 hours, the performance margins in kilometers generate some complications today the average of an electric car in performance is 350 km.

Response N°3

Based on the previous answer, the advantages are in mobility and passenger transport, a decrease in maintenance by a very high percentage, and fuel costs measured at 90% savings with a combustion vehicle.

Response N°4

This has been, on one hand, due to a lack of knowledge about electric vehicle technology, but in many cases after-sales service has also not been adequate in responding to vehicle malfunctions. And performance is for many a limitation.

Response N°5

The technical training to give vehicle maintenance answers is still a limitation today and the after-sales services precisely related to what I mentioned are the difficulties we have today with sustainability and electric mobility.

Response N°6

The governments, in these cases because of the environmental issue and today's problems have a lot to do with the companies that import this type of vehicle, require them to give the necessary guarantees in after-sales and technical services, which have been the weak point of people's decision when it comes to passing an electric vehicle. It is also important to promote training at the educational level, through technical programs for this type of vehicle, both by providing courses on these new vehicle technologies for existing technicians and by offering courses to train new technicians.

Response N°7

As a final insight, there is still much to be done to develop the product. It is very interesting, with significant potential for performance improvements—which, in my four years of personal experience, have advanced considerably—and there is a need to continue working on training and enhancing support for this type of vehicle.

Rodrigo Salcedo Campino. President. Association of Electric Vehicles of Chile - AVEC. CHILE

Response N°1

Citizen participation and public awareness:

- We have developed instances of open dialogue, workshops and seminars to inform and listen to the community about the benefits, challenges and opportunities of electromobility.

- Educational newsletters for users to understand how to take advantage of charging infrastructure and what impact the transition to clean energy has on their quality of life.

2.- Regulatory and Policy Drive:

- We have worked with trade associations, associations, and authorities to propose and support laws and regulations that promote the adoption of electric vehicles and the deployment of public and private charging infrastructure. With a focus on enabling the ecosystem, whether it be associated insurance, maintenance, vehicle repair and charging infrastructure.

- We have participated in technical working groups to incorporate interoperability, safety, and quality standards, with the aim of ensuring an efficient and reliable ecosystem.

Response N°2

The main advantage is related to the topics:

- Economic: reduce transport operating costs and dependence on fuels.

A second advantage that has been well received by users is related to topics:

- Environmental: reduce emissions and noise pollution in cities.

Some disadvantages identified are:

- Regulatory gaps that still hinder the massification of charging infrastructure and private investment.

- Benefits of electromobility, which requires permanent educational programs.

- Initial implementation costs that, although offset over time, remain a barrier for some sectors.

The main factors that have motivated the change we have identified are:

- Economic: Companies that have made the transition by understanding the TCO (total cost of ownership), with fuel and maintenance being the key factors that change.

- Social: Positive changes in drivers and staff working around the last mile, smoother, quieter vehicles, less vibration, etc.

Response N°3

Electric mobility solutions already allow the same functions as combustion mobility, also offering lower operating costs, zero emissions and integration with chargers, where they can see savings, consumption and be connected.

They perform better in public transport, last-mile delivery, small passenger transport, taxis, and for people living outside the cities, meeting the expected performance levels.

Response N°4

The main barriers have been:

- At the individual level: Citizen misinformation about benefits and use, perception of high initial costs and ignorance of the available infrastructure.

- At the institutional level: Regulatory gaps, absence of unified standards and slow processes for permits and installation of charging points.

- At the market level: Limited supply of models, restricted financing and lack of interoperability in charging infrastructure.

Opportunities for improvement

- Strengthen the regulatory framework and tax incentives.

- Expand public and private charging infrastructure with accessibility criteria and national coverage.

- Implement education and citizen engagement campaigns to accelerate adoption and debunk myths.

Response N°5

After-sales service and spare parts: In urban areas, availability is increasing, but in other regions long lead times and limited stock persist, highlighting the need to expand service and logistics networks.

Technical training: There is a deficit of personnel specialized in electromobility and charging infrastructure. Technical training has increased thanks to public and private programs, but it is necessary to accelerate skills certification and continuously update the curricula.

Response N°6

Governments: Develop a robust regulatory framework, with tax incentives, clear electrification goals and regulations for interoperable and accessible charging infrastructure.

Private sector: Invest in innovation, expand the public and private charging network, and generate business models that facilitate access to vehicles and infrastructure.

Citizenship: Participate in consultation processes, adopt clean technologies and demand public policies that favor sustainable mobility.

International organizations: Support with financing, technology transfer and regional training programs.

Response N°7

A key aspect for the success of sustainable mobility is to promote new sources of clean electricity generation, since the growth of the electric vehicle fleet must be accompanied by an energy matrix capable of supplying an ever-increasing demand.

It is important to consider that next-generation vehicles will incorporate higher capacity batteries, which will allow more autonomy, but will also require higher power chargers to reduce charging times. Brands are already demanding higher standards in infrastructure, which implies planning from today a network that combines power, coverage and efficiency.

In this regard, the development of renewable energies, storage systems and smart grids will be essential to ensure that the transition is sustainable, stable and prepared for the needs of the future.

Pablo Enrique Díaz Gómez de Enterría, CEO of Vivestar SA. Uruguay.

Response N°1

EAt Vivestar, we have actively worked to promote sustainable mobility in various sectors. A notable example is our advisory work with the taxi association in Uruguay, where we conducted surveys and technical studies on the experience of the first electric taxis, identifying benefits, obstacles, and concerns to encourage more than 3,000 units to take the step toward the transition. We presented economic analyses that demonstrated the desirability of change, proposed solutions for charging infrastructure and access to financing, prepared studies for the management and second use of batteries, and organized talks to break down socio-cultural barriers.

At the same time, we have developed innovative initiatives such as the region's first hydrogen bike circuit, currently operating at the LATU Innovation Park. We are also working on the conversion of a vehicle to run on hydrogen at the Vivestar Technologies H2 Hub, and we have ongoing projects for industrial parks, tourist areas, and last-mile logistics.

All these actions integrate technical analysis, technological innovation, economic-financial solutions and social accompaniment, with the aim of accelerating the adoption of clean technologies in mobility.

Response N°2

Vivestar's main motivation to promote sustainable mobility is to contribute to decarbonization, introducing clean technologies that are viable and adapted to each sector.

In electric mobility, as in the case of taxis in Uruguay, the benefits for the end user are mainly economic: a substantial reduction in operating costs, lower maintenance expenses, and a longer vehicle lifespan. Our studies showed that financing is not a significant obstacle for this sector; the main challenges are cultural and operational, such as distrust of technology or the adaptation of loading habits. We have worked on addressing them through technical and economic analysis, infrastructure improvement proposals and awareness-raising actions.

In hydrogen mobility, the benefits include zero local emissions, high autonomy, very short refueling times and the possibility of operating in contexts where electric mobility has limitations. However, the central challenge is charging infrastructure, which requires much higher investments than electricity. The cost of hydrogen is not the main obstacle; it is the development of stations and associated systems.

In both cases, change is driven by our taste for innovation and commitment to triple impact, while for end users economic, operational and service advantages are a key driver for adoption. In addition, incentives - whether through financing, direct support or tax benefits - play a decisive role so that companies, which are our main target audience, make the decision to make the transition.

Response N°3

From our experience, sustainable mobility solutions -whether electric or hydrogen-powered- can perform practically the same functions as combustion vehicles, provided that the operation is planned and adapted to the characteristics of each technology. The key is not to expect a "one-to-one" substitution without adjustments, but to understand that the transition involves optimizing processes, routes and habits to make the most of the advantages of each solution.

In the case of electric mobility, vehicles have already demonstrated their ability to meet most urban and interurban needs, with lower operating costs, lower maintenance and zero local emissions. Its main limitation remains autonomy and recharging time, although these factors have improved significantly in recent years.

In the case of hydrogen, autonomy and refueling time are comparable to those of internal combustion, which opens opportunities for sectors where intensive operation does not allow long charging breaks. However, the availability of infrastructure remains a challenge and, therefore, its current implementation requires comprehensive solutions, which include not only the vehicle but also the production, storage and supply ecosystem.

Ultimately, sustainable mobility not only equals the functions of the traditional one, but can surpass them in efficiency, environmental impact and long-term costs, provided it is accompanied by a strategic and collaborative approach to its implementation.

Response N°4

In our experience, barriers depend on the type of technology.

In electric mobility, especially in associations such as the taxi industry, one of the challenges is to ensure that the actors linked to the traditional technology business also find opportunities in the new one, so that they collaborate with the transition instead of resisting it. For the public, access to a wide and reliable charging network is key, since it gives the perception of freedom that the user associates with their vehicle. This aspect reveals the cultural link that society maintains with the automobile and the need to also work on a change of mentality that allows building cities of human scale, where collective transport is part of the same imaginary of freedom. Although there are multiple incentives - fiscal, financing and infrastructure support - it would be key to better coordinate them considering the real patterns of use of each sector. Moreover, a factor that would accelerate the transition is for public institutions to lead by example, sending a clear and consistent signal about the direction to follow.

In hydrogen mobility, the main barrier is the absence of infrastructure and the high initial cost associated with its installation, which generates a significant gap compared to electric mobility. To mitigate it, it is essential to support companies that want to carry out pilot projects, since acquiring early experience with H_2 will allow, in the medium and long term, to form a mix of solutions that takes advantage of the strengths of each technology.

At a general level, the transition requires not only clear incentives and regulatory frameworks, but also a coordinated strategy between the public, private and academic sectors, which maximizes opportunities and minimizes uncertainty in the market.

Response N°5

In electric mobility, although the offer of services and spare parts has grown, relevant challenges persist: the diversity of brands and models, coupled with rapid technological evolution, makes rapid repairs difficult in some cases. Even when spares are available, replacement costs are often high. In sectors such as taxi, the standardization of models would be key to ensure availability and competitive prices, something that the union's management identifies as a critical factor for the sustainability of change.

In hydrogen mobility, the situation is much more incipient: there is no local after-sales infrastructure or availability of spare parts, and there are no vehicles for sale in the local market; all are pilot projects. Technical training in this area is practically nonexistent, requiring a coordinated effort to train specialized personnel and create a support ecosystem.

In both cases, it is essential to advance in the continuous training of technicians and mechanics, as well as in strategies that ensure available spare parts and at competitive costs.

At Vivestar, we promote these capabilities through pilots and the design of projects adapted to each company, with the aim of generating skills, reducing fears or doubts and finding solutions to the contingencies inherent in the adoption of new technologies.

Response N°6

Accelerating the transition towards more sustainable mobility in the region requires a comprehensive approach that articulates governments, the private sector, citizens and international organizations.

Governments must lead with clear and stable long-term signals: coherent policies, measurable objectives and programs that prioritize decarbonization in all modes of transport. This involves coordinating incentives according to the type of mobility (electric, hydrogen, biofuels), promoting standardization to ensure spare parts and services, and setting an example by incorporating sustainable public fleets. They should also move towards tax schemes more aligned with triple impact, gradually introducing emissions taxes in partial replacement of income tax, which rewards innovation and encourages the private sector to experiment and take risks.

The private sector must invest in innovation and pilot projects that allow technologies to mature, generate confidence and consolidate supply and after-sales chains. Similarly, it must actively collaborate with governments, academia, and other stakeholders to scale solutions and share lessons learned.

Citizens play a key role in the adoption of new forms of mobility and in building a cultural vision where sustainable transport is synonymous with freedom, safety, and efficiency. Changing this perception is essential to move towards cities of human scale.

International organizations can catalyze change through financing, technology transfer, and support for regional projects that reduce infrastructure gaps, especially in emerging technologies such as hydrogen.

In all the countries of the region, this transition also represents a strategic opportunity for energy independence. We have the necessary natural resources and, once the technologies are amortised, the economic benefits will be substantial for both electric and hydrogen mobility.

At Vivestar, we believe that the transition will be faster if clear policies, innovative fiscal stimuli, bold business projects, technical training and a profound cultural change that aligns economic, social and environmental interests towards the same goal are combined.

Response N°7

The transition towards sustainable mobility is not just a technological change: it is a deep commitment to our responsibility as part of a whole. It involves recognizing that our decisions impact future generations and that true progress is measured in the balance between the social, the economic and the environmental.

At Vivestar, we believe that innovation is also about serving society, the environment and the opportunities of a fairer future. This requires long-term vision, genuine collaboration and the conviction that each advance must be guided by solid principles and a greater purpose. Only in this way will we be able to build a path in which development and preservation go hand in hand, leaving as a legacy a better world than the one we receive

Fabio Humberto García Lucero. Energy Specialist Early adopter Movilidad Eléctrica Ecuador.

Response N°1

I work at OLADE, an organization that promotes and supports the energy transition processes of its 27 member countries. As part of this process, it includes the decarbonization of the transport sector through the replacement of fossil fuels with electricity and low-net-emission fuels such as biofuels.

Additionally, I hold a master's degree in energy efficiency and am familiar with the advantages of electric vehicles over internal combustion vehicles in terms of efficiency.

Response N°2

The advantages in the case of electric mobility are: greater efficiency, low or no emissions in the operation of the vehicle, lower cost of electric energy compared to gasoline (in my country of residence),

The disadvantages: higher purchase price of an electric vehicle compared to a combustion vehicle of the same performance, insufficient number of recharging stations, longer time needed to recharge energy, little availability of specialized workshops for repair and maintenance, high cost of replacement of batteries.

Response N°3

RESPONSE If there were enough recharging infrastructure, yes in terms of passenger transport, not yet in terms of cargo transport or other modes of transport other than land such as air, sea and river

Response N°4

The relatively high cost of electric vehicles compared to conventional vehicles of equal performance and the lack of charging infrastructure.

Response N°5

I have not yet needed repairs or spare parts, but I have read reviews indicating that electric vehicle repairs take longer than usual, as dealerships typically do not have spare parts readily available in stock.

Response N°6

Governments issue regulations that encourage both the purchase of electric vehicles and the implementation of charging infrastructure. The private sector invest in services related to electromobility, citizens raise awareness of the importance of reducing the pollution of cities and the emission of carbon into the atmosphere and international organizations transfer successful experiences and knowledge from the most advanced and least advanced countries on the subject of sustainable mobility; and advise their Member States in the adoption of policies and regulations that encourage sustainable mobility.

Response N°7

A key aspect for the success of sustainable mobility is to promote new sources of clean electricity generation, since the growth of the electric vehicle fleet must be accompanied by an energy matrix capable of supplying an ever-increasing demand.

National and sectional governments should be responsible for breaking the vicious cycle that occurs with respect to the lack of supply of charging infrastructure due to the still low demand for an insufficient size of the electric vehicle fleet, which in turn is due to the lack of sufficient public charging infrastructure, generating incentives for both the purchase of electric vehicles and the implementation of charging stations. In my country, the electric vehicle fleet is growing significantly but the implementation of charging infrastructure is lagging behind, there are charging stations in the main cities, but they belong to concessionaires or maracas of specific vehicles, but at the level of interurban roads they are practically non-existent, so the use of electric cars is relegated only to the scope of large cities.

Eric Orlich Soley.
President of the Costa Rican Association of Costa Rica.

Response N°1

As for its connection with the topic of mobility, the link is direct. That is why the Association (Costa Rican Electric Mobility Association) was born.

Response N°2

The list of advantages is extensive, starting with the climate aspect, which was the driving force behind the association's creation and growth and the reason for so much effort. Immediately following is the economic aspect: the cost per kilometer in an electric vehicle is only one-fifth of that in a combustion vehicle. Other factors such as comfort since the vehicle has no vibrations, it is more pleasant to drive; with no engine noise, it is also more comfortable. Being able to charge it at home instead of going to a gas station makes life much easier. In Costa Rica in particular, electric vehicles are not subject to driving restrictions, so owners do not lose a day of use as they would with traditional vehicles

Response N°3

Yes, they can perform them; I already clarified this in the previous point. Additionally, aside from the fact that the engine is electric, everything else remains the same..

Response N°4

The main barrier has been knowledge; when they find out the advantages quickly make the change either because they want to save or because they want more comfort. Many people in the IT sector also acquire them because they like all the technological aids they bring. The main purchase barrier now is knowledge, previously it was the higher cost, however at this moment they are the same and the next barrier is the number of chargers available. For drivers who already know how to operate an electric vehicle, they can generally manage using a basic ABC plan. However, for newcomers, there is significant concern about reaching a charging station that may not be working

Response N°5

I consider that they are adequate, In Costa Rica there are already three or four workshops dedicated exclusively to electric vehicles, in addition to those of the agencies. I did not know that there are problems that cannot be solved.

Response N°6

Precisely, charging infrastructure is a vital factor for greater adoption of electric cars. The existing infrastructure is sufficient for the current electric vehicles, if the stations are always in proper working condition. The problem is that they are not always in proper working conditions, and there is no redundancy—if one station fails, there isn't another nearby to rely on. And just a few cases of failure generate significant concern and slow down adoption. So, it is vital that there are more stations across the country and reliable and duplicated for adoption to accelerate.

Response N°7

Well, all organizations, both the government, the private sector, citizens and international entities must play a very active role, we need to consider ourselves in a climate crisis and as if this were a war. Let's all be active and take the necessary measures so that the change does not take place, there is an excess of passivity about it, as if the house were never going to be lit, when it is already smoking through a wall. So what is the key? That the word spreads that we are in crisis and that actions are taken quickly so that there is a citizen conscience everywhere and the changes that have to be made are taken and made.

Martin Piñeyro. Cofounder, Head. SWAPY (a Quantik Group company). Uruguay.

Response N°1

SWAPY was born in the innovation area of Quantik Group as a response to the call for sustainable mobility from a pragmatic and innovative approach, oriented to "delivery" or quick commerce, a sector that has not traditionally shown effective energy transition. Through a system of electric motorcycles with interchangeable batteries and a network of exchange stations, deployed at strategic points in cities, we offer couriers and companies a solution that eliminates the "pains" that slow down their development: long charging times, limited autonomy and high costs.

The solution has been successfully validated by a pilot in Zonamérica, Business Campus and Free Trade Zone, in Montevideo together with The Box, a 4.0 Technology Demonstration Center applied to the Logistics chain, and will be deployed in Montevideo, at ANCAP stations, a state oil company, from September 2025.

SWAPY has the support of the National Agency for Research and Innovation (ANII), the Uruguayan Fuel Distribution Company (DUCSA/ANCAP), the Renewable Energy Innovation Fund (REIF), Newlab, Pedidos Ya and other key players in the Uruguayan innovation ecosystem.

Response N°2

Our main motivation was to solve a paradox: in a global context that demands decarbonizing transport, urban delivery drivers - one of the most intensive segments in terms of kilometers and emissions - remain tied to the combustion motorcycle due to economic, technological and operational barriers.

We saw the opportunity to eliminate those barriers by offering a model in which the user does not buy the battery, but accesses a fast, agile exchange network that maintains continuous operation.

The benefits are clear:

- reduction of emissions, about 3 tons/year of CO_2, and
- reduction of noise pollution,
- lower maintenance costs and a
- more predictable service for logistics and quick commerce companies.

The biggest challenge has been adaptation, both normative and cultural.

- Regulatory barriers are significant and require constant dialogue with the public sector and policy makers to prevent them from becoming a brake.
- Culturally, it is necessary to transform the paradigm and overcome the perception that electric motorcycles are not suitable for work.

Response N°3

The growth of electric buses, van and taxi fleets, together with the sustained increase in sales of private electric vehicles clearly demonstrates that sustainable mobility solutions can replace older technologies, such as those that depend on fossil fuels.

In a broader sense, it is enough to look at cities that have strengthened their network of bike lanes or improved public transport, creating efficient bus corridors or incorporating trains and trams, to observe tangible improvements, evident even to the average citizen.

From our experience at SWAPY, the sustainable mobility solutions we have developed not only match, but in many cases exceed the operational performance of combustion technologies in the urban delivery segment. A delivery person can make the same or even a greater number of deliveries thanks to the lower need for repairs and the speed of battery exchanges in the face of refueling and frequent maintenance services, such as engine oil changes.

The instantaneous response of the electric motor and the absence of vibrations significantly elevate the driving experience. The only aspect in which traditional mobility still maintains an advantage is the availability of supply points; precisely for this reason, our exchange station model seeks to close that gap, offering access to energy with the same ease and ubiquity as a fuel pump.

Response N°4

The main barrier to adoption has been the perception of a high upfront cost, even when the Total Cost of Ownership (TCO) clearly favors the electric option—in Uruguay, we estimate a 30% savings compared to an internal combustion motorcycle—as well as the perceived risk associated with the transition, particularly in sectors like delivery, where margins are tight and downtime is critical. This is compounded by the lack of sufficient public infrastructure and the absence of financing schemes tailored to innovative business models like ours.

However, these same barriers represent strategic opportunities: designing turnkey solutions that integrate vehicle, energy, and maintenance; deploying battery exchange infrastructure at strategic points in the city; and articulating efforts with governments, electric power providers, and logistics companies so that electric mobility ceases to be an isolated pilot and becomes an interconnected, scalable, operational network throughout the region.

Response N°5

One of the pillars of SWAPY is to offer a comprehensive service that ensures that the adoption of electric mobility does not depend on each user or company developing their own technical capacity. Therefore, our model includes preventive and corrective maintenance, fleet management, and specialized technical support. Although in Uruguay the availability of spare parts and qualified labor for electric motorcycles is still incipient, we have worked with manufacturers and suppliers to ensure stock and training, training our own technical team and allied workshops. We believe that, as the electricity fleet grows, the after-sales ecosystem will strengthen, but in the meantime, it is key that actors like us take an active role to ensure operational continuity from day one..

Response N°6

Accelerating the transition towards more sustainable mobility in the region requires coordinated action. Governments must establish regulatory and fiscal frameworks that reward the adoption of clean technologies and facilitate investment in infrastructure. The private sector must innovate in business models that eliminate access barriers, as SWAPY does by offering battery-free electric motorcycles and available energy in seconds. Citizens, on the other hand, must demand and adopt these solutions, understanding their short and long-term environmental and economic impact. And international agencies can play a key role as catalysts for financing and technology transfer, especially in countries where initial scale is a challenge. Only with a shared strategy will we be able to move from pilot projects to robust operational networks that transform the way we move in Latin America.

Response N°7

The transition towards sustainable mobility is not just a technological change, but also a cultural and operational model change. At SWAPY we are convinced that the electrification of urban delivery represents a unique opportunity to combine economic efficiency with a positive environmental impact, generating value for companies, couriers and cities. Our preparatory work in Uruguay confirms that, by eliminating key barriers - such as loading times, high initial costs and lack of infrastructure - the adoption of these solutions can occur naturally.

Our upcoming launch in September will mark the beginning of building an integrated and vertically structured ecosystem, which includes not only electric fleets but also the infrastructure and ancillary services required for their optimal operation. This strategy seeks to replicate itself in new territories, supporting us in strategic alliances and financing with innovative models that allow accelerating the deployment and consolidation of a regional energy and mobility network. Thus, we aspire to set a new standard for sustainable urban transport in Latin America.

Andrés Barentin Calvo,
General Manager Dhemax SpA. CharIn Ambassador for Chile.
Former president AVEC and ALAMOS. Chile.

Response N°1

We have been deeply linked, in fact, we were precursors of electromobility in public transport in Chile, since we collaborated with the piloting of the first units, we actively participated in the implementation of the first 100 buses in Santiago de Chile and since then we have been closely involved with the development of electromobility in Latam and the Iberian Peninsula.
We have implemented and promoted more than 35 charging yards for electric buses in Chile, Colombia, Uruguay and Mexico. In addition, we have promoted consultancies and the establishment of public policies to promote electromobility. Lastly, we have been very active in promoting the advantages of electromobility
.

Response N°2

For our customers, a reduction in operating costs, better vehicle availability, a positive perception from users and customers, and driver satisfaction.

The challenges we have identified I would group them in 2, in the first place, there is still a lack of knowledge and many myths to demolish and that is what we focus on every time we develop a project. Second, the challenge of identifying what are the variables that make a successful operation and project, with a technology that still has limitations for complex operations, I would say that is where we look every time, we approach a client.

As a company, that is precisely what we do, driven by the desire to leave a better world for future generations, with a transformative outlook that aligns with today's business principles, such as total cost of ownership and profitability.

Response N°3

We usually separate the operations with electric vehicles into 3 groups, where we combine the business perspective and that of the state of the art of electromobility. These groups are:

- Routes in which a vehicle travels fewer kilometers than required for the total cost of ownership to match or outperform combustion vehicles —usually in the range of 100 to 200 km per day, depending on the type of vehicle— fall into a group where the performance of an electric vehicle far exceeds that of a combustion one. However, there remains a challenge on the economic side.
- Routes that are a good fit for electromobility usually range between 200 and 500 km per day (depending on the type of vehicle). These are routes that can be covered with the vehicle's range and an opportunity charge during the day. In this case, the performance of electric vehicles allows them to perform the same activities as a combustion vehicle and, in addition, they are tremendously profitable. That said, it requires identifying charging points that allow vehicles to recharge during rest stops or other types of stops. In some cases, this presents a challenge from the standpoint of charging ecosystem.
- Routes in which the state of the art implies operational modifications, in these routes usually what can be done with an electric vehicle is less than what can be done with a combustion vehicle, so they require operational adjustments. However, with the arrival of ultra-fast charging, batteries between 6 and 10 C, and standards such as the MCS, it is expected that this gap will close in the next 2 to 3 years.

Response N°4

Mainly the uncertainty from customers and the financial system toward something unfamiliar, and in some cases—depending on the segment—the availability of models for certain functions, along with the cost of vehicles, which has been decreasing but still falls short of parity.

Response N°5

I believe this area is still lagging: after-sales service is generally good in more densely populated urban areas but tends to be inadequate in less populated regions. In addition, there is still a very strong link between the brands and their own dealers, and little penetration of multi-brand workshops in the world of electric mobility, to generate more competition. I believe that one point where investment should be made is precisely in the formation of human capital.

Response N°6

According to my experience, I believe that the actions are going to educate and standardize, at the regional level there is a very large regulatory dispersion, which in the future will probably affect the operation of vehicles between borders and even the free flow of vehicles through areas of cities. Another important point is to level the authorities' knowledge regarding these new technologies and break myths.

Governments should assume a role of facilitator, dictating rules that approach the advancement of technology, generate a safe development framework, incorporate guarantees to private companies in the development of projects and encourage migration. It should also be channels of information, to get objective data to citizens.

The private sector must be a generator of traction in this process, with the will to innovate, the ability to absorb and distribute the state of the art, and the ability to take risks considering economic retribution, obviously. If we think of the Chilean model, the state defined a regulatory framework that gives certainty and lowers risk, and private investors invested.

In our case, direct contact with citizens is limited. However, I believe their role is to demand from authorities and the ecosystem the best solutions and a forward-looking approach, with long-term thinking.

I believe international organizations play a key role in facilitating knowledge transfer, bringing good practices from more advanced countries to those that are further behind. Another role of international organizations is to democratize access, since in countries with more complex economic situations they can generate opportunities through funds or guarantees that encourage private investors to invest.

Response N°7

A key aspect for the success of sustainable mobility is to promote new sources of clean electricity generation, since the growth of the electric vehicle fleet must be accompanied by an energy matrix capable of supplying an ever-increasing demand.

It seems to me that LATAM should consider itself more as a market and not as many small atomized markets, that could generate competitive advantages. Another point to highlight is the tendency to reinvent everything we have in Latin America, I invite ecosystems to take good practices and adjust them to their realities, as Dhemax we are committed and offer our collaboration in enabling ecosystems and transferring good practices.

Socio-territorial aspects of Sustainable Mobility

Sustainable City and Mobility: Towards a Resilient and Efficient Urban System

The transformation of mobility systems in cities in Latin America and the Caribbean constitutes a strategic opportunity to align urban planning with commitments to energy sustainability, reducing emissions, and improving social welfare. In a scenario characterized by increasing urbanization, climate change and the need to decarbonize transport, it is imperative to review the current mobility paradigm and move towards sustainable, efficient and inclusive solutions (OLADE, 2024).

The city is the territorial area where most of the displacements occur and converge and therefore it is where the highest energy consumption associated with transport occurs. Therefore, rethinking mobility from the urban environment implies not only reorganizing the flows of people and goods, but also transforming the forms of energy production and consumption linked to transport, one of the most energy-intensive and greenhouse gas-emitting sectors in the region (OLADE, 2024; ECLAC, 2023).

Key Dimensions of Urban Sustainable Mobility

To move towards a sustainable mobility model, it is essential to consider three interrelated dimensions: the who (the users), the what (the modes and vehicles used) and the where (the physical and urban environment in which they move). This chapter focuses on the third aspect: the city as a structuring space for mobility, understood as a complex system with inherited infrastructure, physical constraints, and new social, economic, and environmental demands.

In this regard, it is essential to understand that cities cannot be approached as blank canvases. The planning of new infrastructure or the adaptation of existing ones must consider urban resilience, energy efficiency, equitable access, and the capacity to adapt to climate change. Intervention processes must also consider the diversity of local contexts, avoiding standard or replicable solutions without social, cultural, economic and territorial adaptation.

Urban planning, design and planning for energy efficiency

The spatial layout of cities directly influences the energy intensity of transportation. Extensive, functionally segregated and low-density cities favour private car use, increasing energy consumption and emissions. In contrast, compact, mixed-use urban environments with adequate infrastructures for active and collective mobility allow a significant reduction in energy consumption per passenger-kilometre (IEA, 2023; World Bank, 2022).

The promotion of a people-centered urbanism implies integrating principles of mart cities, multimodal mobility, universal accessibility and energy efficiency in urban planning. This systemic vision must articulate transport policies with those of territorial planning, land use, housing and energy transition. Urban infrastructure, in this context, becomes a key instrument to induce behavioral changes and more sustainable modes of displacement.

Urban Measures to Promote Sustainable Mobility

Without being exhaustive, the following are some lines of action that can contribute to building more efficient and sustainable cities from an energy point of view:

- Reduction of urban speed through "30 km/h Streets," which enhance road safety and prioritize non-motorized modes in specific areas.
- Exclusive lanes for public transport (BRT, trams or electric buses) that optimise passenger flow and reduce specific energy consumption.
- Implementation of safe and connected bike lanes with transfer nodes and activity centers.
- Tactical urban planning interventions to recover public space, reduce car use and promote walking and cycling.
- Multimodal transfer stations with a smart design approach (SM Martesign), integrated with electric charging infrastructure.
- Promotion of last-mile active and electric modes such as bikes, skateboards, and delivery tricycles in dense urban areas.
- Digital infrastructure for the monitoring and management of energy demand in urban mobility (sensors, big data, AI).

The combination of these measures must be designed according to a "mix of solutions" approach adapted to local conditions, recognizing that there are no unique recipes. The urban and socioeconomic diversity of the countries of the region requires flexible, contextualized and evaluable policies.

Integrated approaches: energy, environmental, economic and social sustainability

Energy approach

Transport represents more than 39% of final energy consumption in the region (OLADE, 2024). Urban mobility concentrates a significant proportion of this consumption, mainly associated with petroleum derivatives. Promoting energy efficiency in this sector involves adopting low consumption technologies, electrification of public transport and demand management measures.

Between 2000 and 2022, an average improvement of 2.55% per year was observed in the energy efficiency of transport in the region, being the sector with the greatest savings potential (OLADE, 2024). Even so, this progress is insufficient to reach regional decarbonization targets. It requires systemic interventions that integrate urban planning, clean technologies and modal shifts.

Economic approach

Investments in infrastructure for sustainable mobility generate multiple positive externalities, such as reduction of costs in public health, reduction of fuel subsidies, generation of green employment, revitalization of public transport, and reduction of household spending on mobility. Likewise, the electrification of urban transport can contribute to stabilizing national energy balances by reducing dependence on imported hydrocarbons.

Environmental approach

Cities in the region concentrate high levels of air pollution, noise and greenhouse gas emissions, largely derived from motorized transport. Sustainable mobility can reduce emissions by more than 30% in urban areas by promoting modal shifts and clean technologies. This transformation is critical to meet the Nationally Determined Contributions (NDCs) and the Sustainable Development Goals (SDGs), in particular SDG 11 (Sustainable Cities) and SDG 7 (Affordable and Clean Energy).

Social approach

Equitable mobility must guarantee universal and affordable access to transport, especially for the most vulnerable groups. Women, the elderly, young people, people with disabilities and inhabitants of peripheral areas must be considered as protagonists of urban design. Sustainable mobility must reduce inequalities, expand opportunities and improve the quality of life at all levels of society.

Projections and recommendations for future editions of the White Paper on Sustainable Mobility

Sustainable urban mobility, from an energy perspective, represents a priority line for technical analysis in the region. Therefore, it is essential that future editions of the White Paper on Mobility expand this chapter towards more detailed and comparative studies that include:

- Specific diagnostics by city, with indicators of energy efficiency in urban transport.
- Assessments of the impact of public electromobility on the energy matrix.
- Financing and cooperation models for the development of urban electric recharging infrastructure.
- Regional mapping of last-mile initiatives and their effects on energy consumption, congestion, and access.
- Replicable success stories adapted to Latin American contexts.

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Gender and Electric Mobility in Latin America and the Caribbean

This article is authored by the Sustainable Mobility Unit of the United Nations Environment Programme.

Background

The transition to electric mobility represents a significant opportunity to advance both gender equality and climate goals. Latin America and the Caribbean must seize this moment to ensure that the region's vehicle fleet decarbonization efforts are not only effective, but also fair and inclusive, leaving no one behind.

Electric mobility is transforming the transport sector, replacing systems consolidated for decades around internal combustion engines (ICEs).

This change is redefining technologies, production processes and consumption behaviors, with important repercussions for employment. As traditional roles in vehicle manufacturing, sales, and maintenance evolve or disappear, new opportunities arise in charging infrastructure, renewable energy, battery management, recycling, and digital services.

To ensure a just and inclusive transition, it is essential to invest in capacity development and create equal opportunities in the new sectors. Women must be part of this process, with specific efforts to remove barriers and promote their participation as transport users, workers, and decision-makers. If managed effectively, the transition to electric mobility has the potential to generate millions of green jobs while boosting gender equality and climate goals.

In Latin America, women represent only 15% of the workforce in the transport sector, and their presence in managerial positions is reduced to single-digit figures. As electric mobility grows, closing this gender gap will be fundamental, not only to build a more inclusive sector, but also to face the shortage of personnel in functions ranging from driving to the new roles in manufacturing, assembly and digital services linked to electric vehicles (EVs).

Building a more inclusive transport sector is essential, since the quality and policies of public transport have a great impact on women, who depend on this service to a greater extent than men. In Latin America, evidence shows that women spend on average, 30% more time traveling than men and walk between 11% and 16% more to complete their daily tasks. These inequalities directly limit women's access to employment, essential services and opportunities, affecting their economic participation and quality of life.

However, a gender gap persists in the planning and design of mobility networks, which continues to lead to systems that often do not respond to the needs of women. With the development of electric mobility, public policymakers must adopt strategic measures to guarantee the development of capacities of women on a large scale and promote schemes that promote their active participation, so that transport systems reflect and respond to their daily realities.

Implementing **large-scale capacity development programs** is fundamental, not only to guarantee the inclusion of women, but also to sustain the growth of the electric mobility sector. These programs must cover both jobs where high, medium and low capacities are required throughout the entire value chain of electric vehicles, also ensuring that women are represented in leadership roles and in decision-making.

New highly skilled positions are emerging in areas such as vehicle design, software development, and electronic component assembly. To respond to the growing demand for talent, industries are increasingly turning to the growing number of women graduating in science, technology, engineering, and math (STEM).

At the same time, the transition to electric vehicles is generating opportunities for women in manufacturing and transportation operations. Historically, the transport sector has shown an especially wide gender gap both in managerial positions and in technical and operational functions. The participation of women in planning and policymaking is essential for the development of gender-inclusive transport systems. When women hold positions as directors of transport agencies, urban planners or public policy makers, they can play a key role in the design of systems based on electric mobility that are more inclusive, accessible and adapted to the needs of all people.

For this purpose, collaboration between academia, industry, and governments is essential, not only to build the electric mobility workforce but also to ensure that women have the tools to lead in this field. Universities must play a central role in the retraining and training of women and men, responding to the changing demands of the sector and closing persistent gaps in leadership and technical fields.

National and regional e-mobility policies with a gender focus are essential. These efforts help close persistent gaps in the transport sector by highlighting the role of women, guiding investors, and supporting education and communication with a gender-informed approach. However, many current policies remain gender-neutral, limiting their transformative capacity.

Colombia stands out as a regional leader in promoting gender equality through electric mobility, demonstrating how multi-stakeholder collaboration and strategies with a gender focus can generate more inclusive transport systems. At both the national and city levels, coordinated action among public institutions, transport operators, and training entities is helping to close gaps and ensure that women actively participate in the transition.

In Bogotá, the women-led public transport company **La Rolita operates** a fleet of 195 electric buses, the first of its kind in Latin America (C40 Cities/TUMI, 2023). The company demands training for female drivers and actively promotes their incorporation into non-traditional roles, setting a solid precedent for gender equity in public transport services.

The addition of 172 electric buses in February 2022 generated 502 green jobs, while local assembly created more than 1,400 additional jobs, including 165 for women. This achievement has been enabled by public policies and institutional partnerships that prioritize the inclusive development of the workforce.

The District Department of Women of Bogotá (DDM) plays a central role in facilitating the participation of women in the transport sectors. Through its 18 Digital Inclusion Centers, the DDM offers training in digital skills and supports women in obtaining Public Service driving licenses, a requirement that often constitutes an economic barrier. The institution has also supported technical women of La Rolita to obtain the necessary certifications and has provided specific support for training in efficient driving, expanding access opportunities throughout the entire value chain of electric mobility.

In conclusion, **Latin America and the Caribbean is at a decisive moment**. The transition towards electric mobility is not just a technological change: it is an opportunity to redefine the transport sector as inclusive, equitable and sustainable. Integrating gender equality at each stage of this transition - from policies and planning to capacity development and leadership - will allow the full potential of electromobility to be unleashed.

This requires intentional actions: specific training programs, policies with a gender focus and a significant representation of women in decision-making spaces. With political will, strategic alliances and inclusive frameworks, electric mobility can become an engine of both climate action and social transformation, ensuring that no one is left behind.

Electromobility as a driver of change

"The role of electromobility as an engine of change: towards a just and transformative gender transition" is a project implemented by the United Nations Environment Programme (UNEP), with funding from the German Federal Ministry for Economic Cooperation and Development (BMZ). Its objective is to ensure that the transition towards electric mobility in low- and middle-income countries includes and promotes the interests of women, contributing to a more just and gender-transformative transport sector.

The project is developed within the framework of the UNEP Global Electric Mobility Program and includes six pilot countries: Colombia, Ecuador, Indonesia, Vietnam, Kenya and Uganda. In each case, support is provided for the formulation of gender-focused electric mobility policies, inclusive workforce training is promoted, and institutional capacities are strengthened so that women are not only beneficiaries but also active leaders and decision-makers in the transition to electric mobility.

For more information, see: *International baseline report on gender and e-mobility*

Context between Gender and Mobility in Ecuador

Ecuador is at an early but promising stage in its transition to electric mobility. In 2021 it approved the National Electromobility Strategy and in 2023 it formalized the National Policy on Sustainable Urban Mobility (PNMUS). Both frameworks explicitly recognize gender equity as a cross-cutting axis; however, greater institutionalization is required to ensure that the participation of women is maintained and expanded throughout the transport sector.

Women represent only 9% of the workforce in transport and storage activities (ENEMDU 2023), and their presence in technical and leadership positions remains limited. Even so, there are local initiatives that show potential for change. In Quito, campaigns such as Bajale al Acoso and the incorporation of a design with a gender perspective in the Metro - where 40% of the staff are women and 18 of them lead the system - are improving safety and representation. Cuenca's Tram system has incorporated female operators, and its regulations promote inclusion and the prevention of violence, while Guayaquil's Sustainable Urban Mobility Plan integrates a gender perspective in terms of safety, accessibility, and workforce capacity development.

Mobility patterns also show gender differences: 47.6% of women use public transport, compared to 43% of men, and women walk more frequently. However, the perception of insecurity is high: 90.1% of women in Quito consider public transport unsafe, which turns harassment and violence into barriers to access, employment and economic participation.

Ecuador's electromobility ecosystem has a growing participation of the industrial sector -from electric bus operators in Quito and Guayaquil, to pioneering cooperatives of electric taxis in Loja and Cuenca—, as well as the active involvement of ministries, municipalities, development banks and civil society. However, the lack of systematic gender-disaggregated data limits evidence-based policymaking.

Key actions identified for Ecuador include:

- Expand training with a gender focus for technical, operational and leadership roles in the electric vehicle value chain.
- Integrate gender considerations into all stages of electric mobility planning, from infrastructure design to financing.
- Strengthen safety measures in public transport to encourage greater use and employment of women.
- Improve data systems to record and analyze women's participation and mobility patterns.

Al incorporar estas prioridades en las políticas, la planificación y la inversión, Ecuador puede garantizar que su transición hacia la movilidad eléctrica sea un motor tanto de acción climática como de igualdad de género.

For more information, see: *Ecuador baseline report on gender and e-mobility*

Gender and Mobility Context in Colombia

Colombia has positioned itself as a regional leader in electric mobility, supported by a solid regulatory framework that includes the National Strategy on Electric and Sustainable Mobility (2019), the Electric Mobility Law (Law 1964 of 2019) and urban mobility plans that integrate sustainability and gender inclusion objectives. Although these policies recognize the importance of inclusion, their effective implementation requires stronger institutional mechanisms to close the gender gaps in the sector.

Women represent 8.6% of the workforce in transport and storage activities (GEIH 2023) and are underrepresented in technical, operational and decision-making roles. However, municipal initiatives show progress: in addition to the advances reflected in La Rolita and Transmilenio, the Medellín Metroplús has trained and employed women as operators of electric buses; and the Cali MIO has implemented campaigns against harassment and measures to improve passenger safety.

Mobility surveys indicate that 62.8% of women in Bogotá use public transport, compared to 54.6% of men, and that they are more likely to make multipurpose trips and travel with their dependents. However, safety concerns persist: 86% of women in Bogotá report feeling unsafe on public transport, which limits their access to opportunities and conditions their travel decisions.

Colombia's electric mobility ecosystem benefits from a growing fleet of electric buses - more than 1,600 in Bogotá, one of the largest outside China - and the active participation of ministries, local governments, transport agencies, private operators and development banks. The absence of comprehensive data disaggregated by gender in employment, training and use patterns limits the ability to design specific interventions.

Key actions identified for Colombia include:

- Expand training programs for women in technical, operational and leadership roles in electric mobility.
- Integrate gender considerations into planning, recruitment and monitoring processes.
- Strengthen safety measures and infrastructure to increase women's confidence in public transport.
- Improve the collection of sex-disaggregated data to guide policies and investment.

By incorporating these priorities, Colombia can leverage its leadership in electric mobility to simultaneously advance climate action and gender equality.

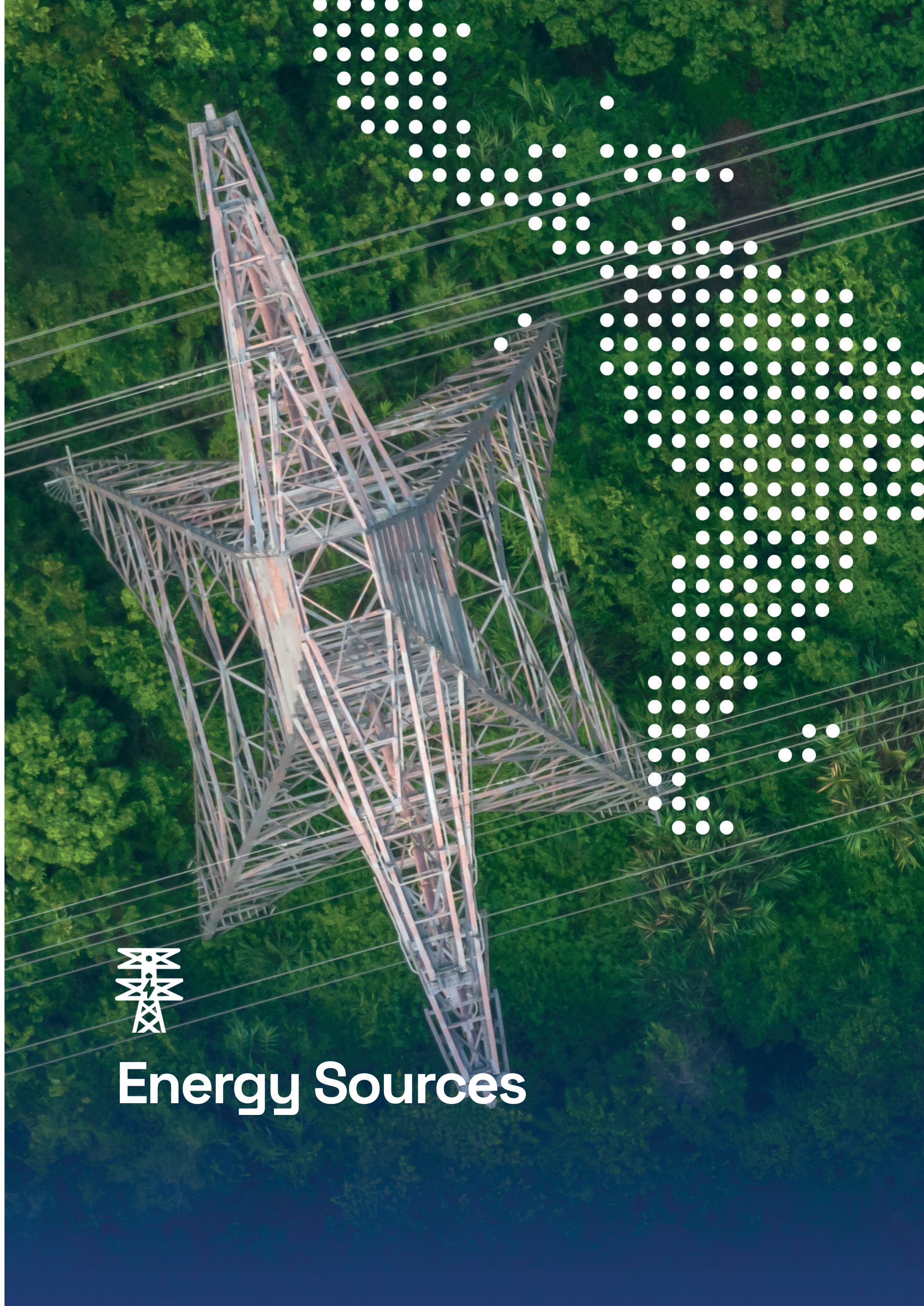
For more information, see: Gender and electric mobility baseline report for Colombia

Within the framework of the mandate of the Forum of Ministers of the Environment of Latin America and the Caribbean, advances towards electric mobility with a gender focus in countries such as Ecuador and Colombia reflect the regional commitment to climate action and equality.

In Ecuador, progress shows that national policies can translate into concrete improvements in security, access and labour participation. In Colombia, the expansion of electric buses, along with training programs for operators and campaigns against harassment, shows how cities can lead by integrating a gender perspective in all stages of planning and implementation.

Both cases confirm that closing gender gaps in mobility - through disaggregated data, technical training, security measures and inclusion mechanisms - is not only consistent with regional commitments on environment and equality, but also strengthens the resilience, social justice and sustainability that the Forum promotes as part of its common agenda.

For more information, see: *Regional Working Group on Gender and Environment of LAC*



Energy Sources

Electricity Generation in LAC: A Key Pillar for Sustainable Mobility

Introduction

One of the key elements in the transition towards sustainable mobility systems in Latin America and the Caribbean is the progressive replacement of vehicles with internal combustion engines, which use fossil fuels, by units powered by electric energy. This change not only has technological or environmental implications but is of strategic importance from an energy point of view, as it has a direct impact on the diversification of the energy matrix, the security of supply and the energy efficiency of the transport sector.

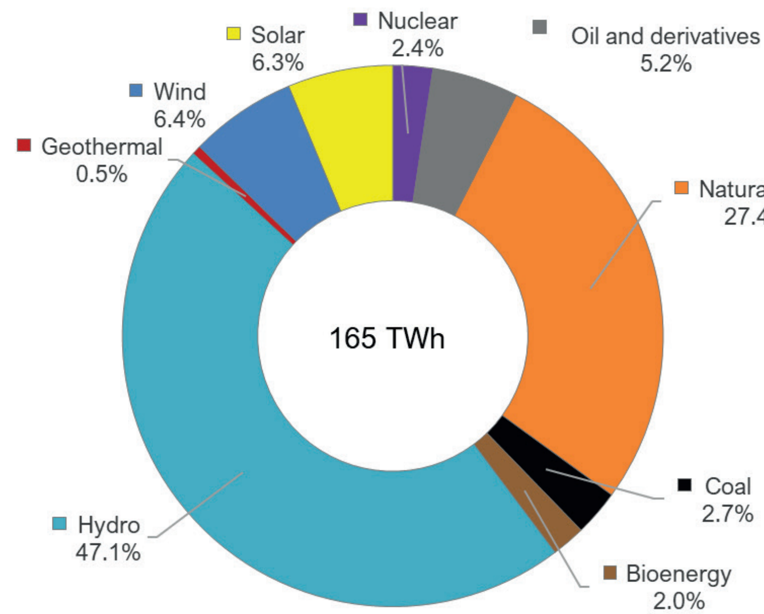
It should be noted that the benefits of this electrification of transport are maximized when electricity comes from renewable generation sources. In this regard, Latin America and the Caribbean is in a privileged position worldwide: more than 60% of the electricity in the region comes from renewable sources, mainly hydroelectric, wind and solar (OLADE, 2024). This structural feature offers a comparative advantage to move towards decarbonized mobility, by simultaneously reducing greenhouse gas emissions and dependence on imported fuels.

It is important to emphasize that this transition does not manifest itself in a homogeneous way in all the countries of the region. There are marked differences in the composition of national electricity matrices. Countries such as Uruguay, Costa Rica and Paraguay, for example, generate more than 90% of their electricity from renewable sources, which makes them regional benchmarks in terms of the enabling conditions for a sustainable electrification of transport (OLADE, 2024; IEA, 2023).

Electricity Generation in LAC by Source as of March 2025

In March 2025, total electricity generation in Latin America and the Caribbean (LAC) reached 165 TWh, representing a 5% year-over-year increase compared to March 2024. Of this total, 47.1% was generated from hydropower, 27.4% from natural gas, 6.4% from wind energy, 5.2% from oil and derivatives, 6.3% from solar energy, 2.4% from nuclear energy, 2.7% from coal, 2.0% from bioenergy, and 0.5% from geothermal sources. See Figure 42.

Figure 42. Electricity generation by source in LAC, March 2025 (%)



Source: sieLAC – OLADE 2025

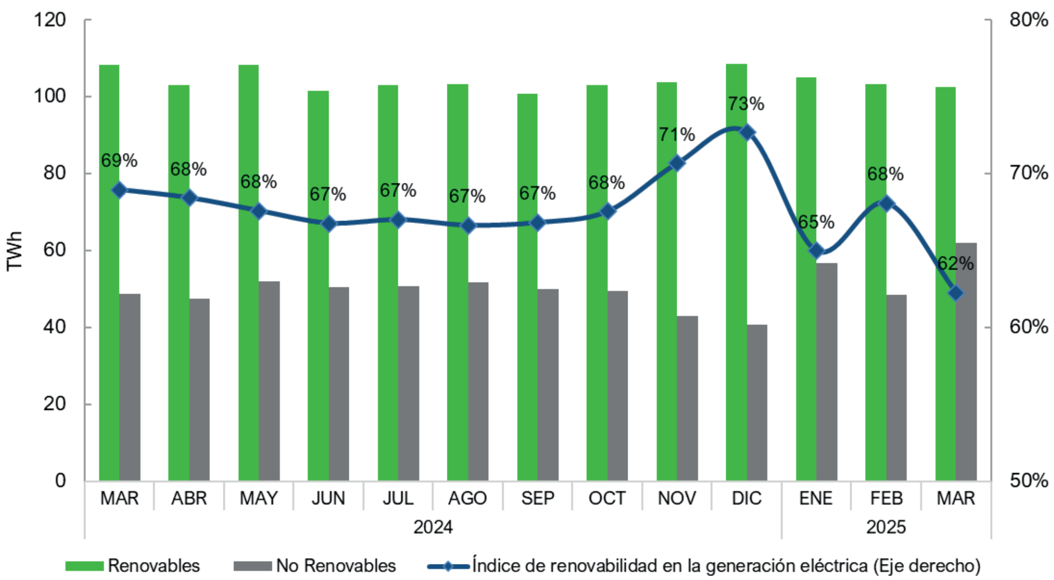
Renewable power generation index.

In LAC, during the period from March 2024 to March 2025, this indicator ranged between 62% and 73%.

In March 2025, this indicator reached 62% , recording one of the lowest monthly values for the period analyzed, due to the increased generation with fossil energy sources and the decrease in hydro and wind generation. See Figure 43.

It is worth mentioning that seven countries in the region exceed renewability index values of over 75%, with Paraguay leading the ranking at approximately 100%, followed by Costa Rica, Brazil, Uruguay, Venezuela, Colombia, and Belize. See Figure 44.

Figure 43. Renewability index in electricity generation, LAC



Source: sieLAC – OLADE 2025

Figure 44. Map of the Renewability Index in electricity generation in LAC, March 2025

Final Remarks

In summary, the electrification of transport is a key driver of energy efficiency and energy transition in Latin America and the Caribbean. Harnessing the high share of renewable energy in the regional power matrix allows simultaneous progress on three strategic objectives: emissions reduction, increased energy independence, and improved quality of transport services. To this end, it is crucial that public policies on mobility are articulated with national and regional energy strategies, integrating energy performance indicators, incentives for technological innovation and financing mechanisms that favor cleaner, safer and more efficient mobility.

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Good Practices

Author: Ministry of the Environment of Chile

The CLETS Project and its relevance in sustainable mobility in Chile

The initiative has allowed the formulation and execution of initiatives that promote sustainable mobility in its multiple dimensions, while contributing to overcoming challenges such as the need to strengthen technical capacities and the availability of specialized tools, key elements for an effective and sustainable transition.

The Minister of the Environment María Heloisa Rojas Corradi and the Minister of Transport and Telecommunications Juan Carlos Muñoz Abogabir, together with authorities of AGCID and CAF on the start day of the project.

The Project "Support to the Chilean Sustainable Transport Strategy" (CLETS), financed by the Global Environment Facility (GEF) and implemented by the Development Bank of Latin America and the Caribbean (CAF), is executed by the Ministry of the Environment of Chile (MMA) and administered by the Chilean Agency for International Development Cooperation (AGCID), has been fundamental to strengthening climate action in the transport sector.

This project has allowed the formulation and execution of initiatives that promote sustainable mobility in multiple dimensions, while contributing to overcoming non-financial challenges. These include the need to strengthen technical capacities and the availability of specialized tools, key elements for an effective and sustainable transition.

The objective of the "CLETS Project" is to verify the positive impacts on greenhouse gas emissions of the use of zero and low emission transport technologies in integrated urban public mobility systems.

The project comprises the following two components:

1. Promoting regulatory, planning and regulatory frameworks that encourage the adoption of integrated low-emission mobility systems. This through participation, knowledge management and capacity development within the framework of a Chilean Low Emissions Transport Strategy (CLETS).
2. Implementation of pilot initiatives in the use of zero and low emission transport technologies in integrated urban public mobility systems, which put into operation financial mechanisms to support integrated low-emission mobility systems, demonstrating their benefits.

Coordination of CLETS Project with the Ministry of Transport and Telecommunications of Chile (MTT)

Sustainable mobility, which includes a set of practices and modes of transport, has as its main goal to meet the mobility needs of people and goods while minimizing environmental impact and improving the quality of life of present and future generations. This challenge is particularly relevant in Latin America and the Caribbean, a region characterized by accelerated urban expansion, deficits in its territorial planning, high levels of informality and inequality, and a marked vulnerability to the effects of climate change.

In this context, the Ministry of Transport and Telecommunications (MTT), through the Road and Urban Transport Program (SECTRA), has adopted sustainable mobility as a guiding principle of its management. This approach is embodied in a series of strategic actions that prioritize electromobility, non-polluting modes of transport, the development of mass public transport systems, the promotion of rail transport, and the promotion of active mobility.

The key to this strategy lies in the creation of solutions adapted to the local context, based on local knowledge, citizen participation and regional cooperation. Transport is conceived as a catalyst for collaboration between the government, the private sector and civil society, to build more livable, socially equitable and resilient cities.

Fundamental Pillars of MTT Action

I. **Quality Public Transportation:** Investment in low-emission mass bus systems and high service standards is prioritized, with a strong emphasis on regional development and decentralization.

II. **Active Mobility:** The use of cycling and walking is encouraged through the creation of safe, accessible and well-integrated infrastructure in the urban environment.

III. **Low-Emission Transport:** The development of clean technologies, the electrification of transport, and the use of efficient and accessible systems are being promoted.

IV. **Integrated Urban Planning:** The vision is reinforced that mobility cannot be addressed solely through transport measures but must be intrinsically linked to urban development. This involves promoting compact, mixed-use environments that reduce the need for travel and optimize efficiency.

Among the most outstanding initiatives of the CLETS project in this field are:

- The Sectoral Plan for Climate Change Mitigation and Adaptation in the Transport Sector, which sets out a roadmap for reducing emissions and adapting to the impacts of climate change.
- The development of an Open Mobility Data Strategy, aimed at democratizing access to information for more efficient and transparent planning.
- The implementation of Demonstration Pilot Projects to test and validate new mobility technologies and models.
- The digitalization of collective taxi routes, which optimizes the efficiency of the service and the user experience.

These projects have initiated a joint line of action between both ministries, laying the groundwork for lasting collaboration.

The synergy and commitment of both ministries promise tangible benefits for all users of transport systems, paving the way for a future that is more sustainable and prosperous for society.

The CLETS Project and its pilot initiatives

The CLETS project includes the development of four demonstration actions in different regions of the country, outside the Metropolitan area. Each of them has defined objectives, concrete benefits and an approach oriented to its potential for replicability at the regional level:

- **Antofagasta: A roadmap for the city**

Antofagasta is a key point in the electrification of major public transport in regions, promoting the use of electric buses and clean technologies in public transport. The CLETS demonstration action in this city aims, through collaboration with local electromobility stakeholders and the dissemination of its results, to develop a diagnosis of the regional situation and a Roadmap for the development of sustainable transport in the city. .

- **Concepción: Public Bicycle System**

The objective of this pilot is to implement a public bicycle system in Greater Concepción, as an initiative that integrates bicycles into the public transport network while ensuring operational sustainability and accessibility. The project contemplates the definition of technical and economic bases for the tendering of the service, along with awareness campaigns that promote the use of active mobility among transport users.

The expected benefits of this demonstration action include the reduction of emissions and traffic congestion, the promotion of healthy habits, and the implementation of a bicycle system fully integrated into the city's public transport network.

- **Lebu: A Regulatory Pilot for Minor Public Transport**

The objective of this initiative is to promote electromobility in colectivos (shared taxis with fixed routes that operate in Chile) in the city of Lebu. Considering the state subsidies for the acquisition of electric vehicles (with a projection of 15 units between 2025-2026), the implementation of fast charging infrastructure is proposed (one in Lebu and another on the route to Concepción). Simultaneously, progress will be made in exploring business models that enable the installation of additional public charging infrastructure.

The expected benefits of this initiative are to promote electric mobility in cities where, due to their urban and demographic characteristics, colectivos (shared taxis) serve as the main means of public transport. The incorporation of fast charging infrastructure will reduce autonomy anxiety, encourage technological adoption by operators and, ultimately, improve the experience of regional public transport users, contributing to the consolidation of a sustainable transport system in rural and tourist areas.

- **Valdivia: Electro terminal of electric bus fleets**

Training day on charging infrastructure with public transport bus operators (ABB Chile facilities)

The objective of this initiative is to promote the transformation of the major public transport fleet toward electromobility through the development of publicly accessible charging infrastructure. The implementation of a multimodal e-terminal is planned, allowing various electromobility users to charge their vehicles, including major public transport, taxis, private cars, and last-mile delivery services, thereby promoting interoperability and energy efficiency.

The expected benefits of this demonstration experience are the significant reduction of polluting emissions, technological modernization and the generation of local knowledge.

These four demonstration initiatives of the CLETS project aim not only to demonstrate technological feasibility but, above all, to develop business models and regulatory frameworks that ensure their financial and operational sustainability over time. Its ability to generate replicable learning and methodologies is key, which can be scaled within Chile and in Latin American cities with similar profiles.

The Chilean experience shows that the articulation between public policies, technological innovation, strategic subsidies, articulation and multisectoral participation of the state and institutions is essential to consolidate electromobility as a central axis in sustainable urban mobility.

With this systemic and long-term perspective, the aim is to position Chile as a regional benchmark, generating lessons that can inspire and guide sustainable mobility processes across Latin America.

Author: Ministry of Transportation and Communications of Chile

Santiago de Chile and the transformation of public transportation toward electromobility[I]

Santiago de Chile's experience in incorporating electric buses into public transport has been one of the most outstanding in Latin America and the world. The RED Mobility System (hereinafter, System) has established itself as a global benchmark in sustainable mobility and the city with the most electric buses outside China[II] . By March 2026, Santiago will have more than 4,400 electric buses, reaching 68% of its fleet with zero emissions.

This process responds to a combination of state public policies, with long-term views that go beyond governments, with solid regulatory frameworks and innovative financial strategies. All of this is accompanied by the political conviction that public transport can and should improve people's daily lives.

A clear example was the first National Electromobility Strategy, published in 2017, which enabled the arrival of the first two electric buses to be tested in the System. This strategy, updated in 2021, established the objective that, by 2035, 100% of new public transport acquisitions must be zero emissions, and that all buses in the Public Transport System must be electric by 2040. The actions of different governments since then have been framed in continuing and strengthening these objectives, even significantly advancing them, with the first 100% electric tender carried out in 2023, 10 years earlier than planned.

1. Legal and financial keys to a pioneering model

Legal. The Chilean case is based on strategic legal decisions. Law No. 20.378 approved in 2009[III] , created a national subsidy for public transport that has been fundamental to ensure sustainable, permanent and long-term financing for the operation of the System. The subsidy is a key social investment for the modernization of public transport, including its shift toward electromobility, creating mechanisms that guarantee payment flows while ensuring legality, traceability, and transparency.

The same law established an Expert Panel, an autonomous technical body responsible for determining quarterly adjustments in rates, in order to guarantee the financial sustainability of the System as a whole. On the other hand, the resources[IV] from the fees and the subsidy are managed autonomously and centrally by the aft financial administrator, whose assets are independent of the System's own resources . Thus, the Ministry of Transport and Telecommunications of Chile (MTT), through the Metropolitan Public Transport Directory (DTPM), coordinates and instructs payments to the companies that provide the services according to the required standards.

In parallel, in 2015 Chile strengthened Law No. 18.696 and other related regulations[V] , granting the Ministry of Transport and Telecommunications (MTT) greater powers to intervene in and regulate public transport at the national level. In the aforementioned law, the MTT is empowered to pronounce on the conditions and requirements incorporated in provision contracts, in addition to requiring that the assets involved be considered **Assets Affected to the Concession**. These assets must be registered in the Register of Affected Assets and, in the event of termination of the operator's contract, transferred to the new company if they still have a remaining useful life. This mechanism guarantees the continuity of the service and protects the essential assets of the System, allowing their use and the full payment of their fees until the end of their useful life, regardless of who operates them.

Financial. The evolution of the regulatory instruments applied played a crucial role in shaping the fleet of electric buses and the acquisition of charging infrastructure. Chile applied a robust business model that reduces barriers to entry, generates competition and mitigates financial risks. The key was to separate the ownership of the assets (terminals, buses and charging infrastructure) from the operation, ensuring that the full payment of the fleet and infrastructure was maintained throughout its useful life, independent of the operator.

In particular, three elements were decisive: Provision Contracts, Fleet Share and Assets Affected to Concession. The **Provision Contracts** allow private operators to enter into agreements to use and enjoy the goods necessary for the provision of the service, such as buses or charging infrastructure, as long as they are approved by the MTT, which ensures compliance with standards and the sustainability and efficiency of the System.

In the Provision Contracts, the **Fleet Quota** is regulated—a fixed lease fee that covers capital and debt—which is transferred directly to the financier through the AFT. To this end, the concessionaire must mandate, by assigning the revenues it receives from providing transport services, that the payment be made directly to the financier of the asset. In this way, the risk of delay or non-compliance in the payment of fees is reduced, giving financial certainty by separating this flow from the quality indicators associated with the operation.

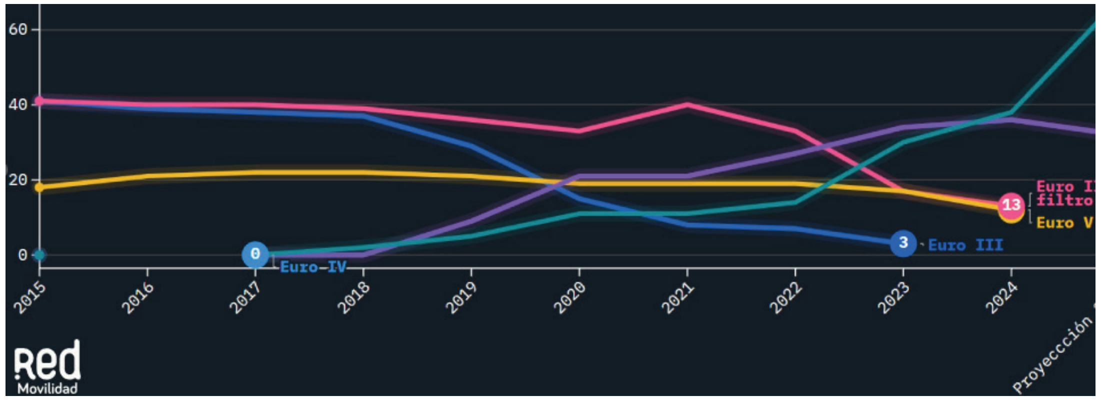
An additional milestone was the modernization of the General Law of Electrical Services, which opened the figure of "free customers"[VI] . As a result, operators were able to negotiate contracts directly with power generators, gaining access to cleaner and cheaper energy. This point is of great interest to countries in the region, since it articulates electric mobility with the ongoing energy transition.

At the same time, the State assumed a decisive role in infrastructure: first with the expropriation of terminals and then, through the public company "Desarrollo País", which is responsible for the acquisition, lease and, from 2025, for the qualification of electroterminals.

2. Santiago de Chile’s bet: 100% electric tenders

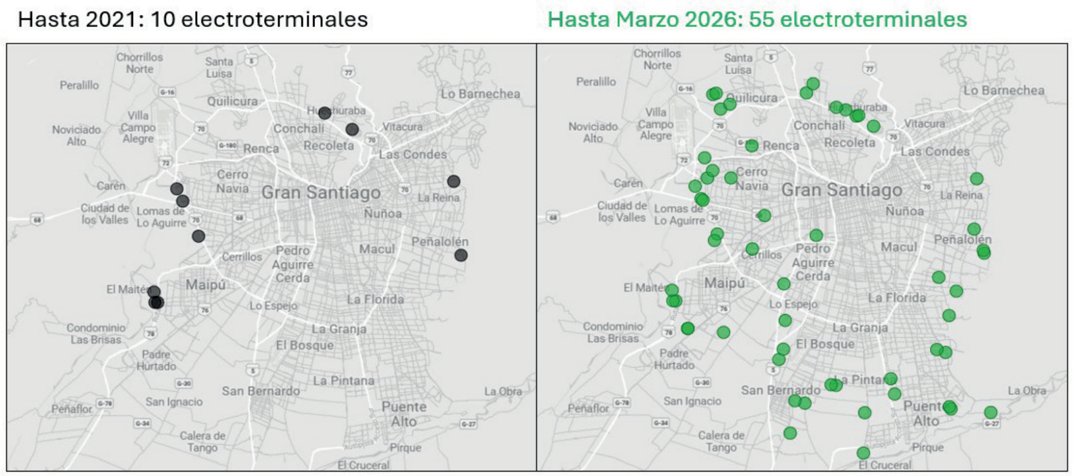
If in March 2022 the Red Mobility System had less than 800 electric buses and 10 electroterminals, by March 2026 it is expected to reach 4,406 electric buses and 55 electroterminals, with which 68% of the fleet will be electric, consolidating Santiago de Chile as the city with the most electric buses outside China..

Graph 1: Technological Evolution of the Mobility Network System Fleet, 2015 – 2025



Source: 1st Metropolitan Public Transport Directory Electromobility Report [I, VII]
Author's original image.

Figure 1. Charging infrastructure and electric fleet by commune, Projection 2026



Source: Own Elaboration, Metropolitan Public Transport Directory [I].
Author's original image.

These advances are part of the progressive design of tenders aimed at electromobility. The experience gained from the 2019 tender allowed for the design of the 2023 and upcoming 2025 tenders, in which fleet provision and operation are jointly tendered, requiring that 100% of new vehicles be electric, in line with Chile's climate change commitments.

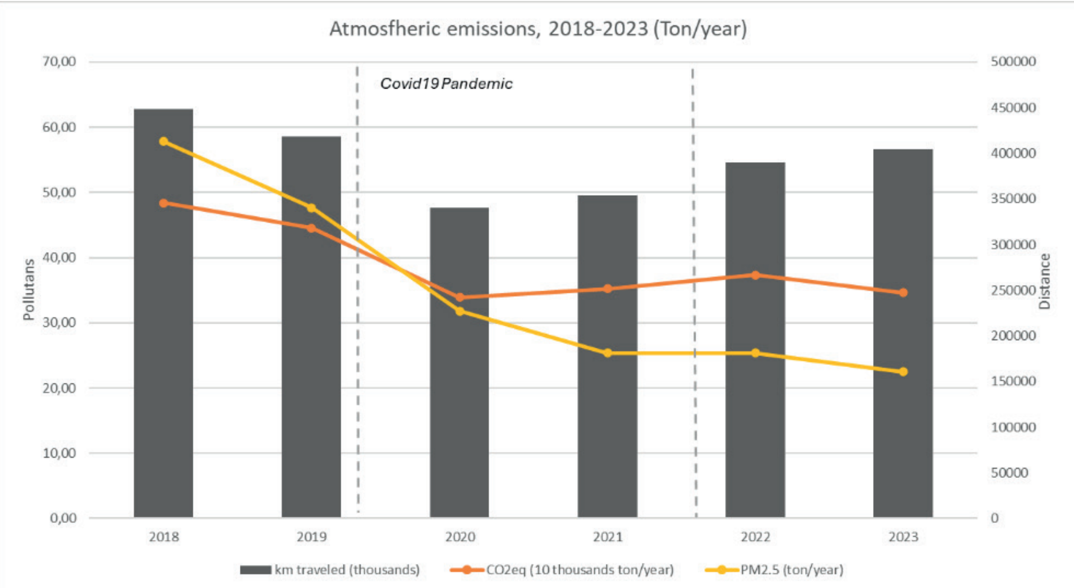
The 2023 tender, awarded in 2024, will allow the incorporation of 1,800 new electric buses and 20 new electro-terminals between 2025 and March 2026, benefiting 3.5 million people. As a result, Santiago will have advanced its National Electromobility Strategy's climate goals by more than a decade[VIII], which had projected zero emissions for public transport starting in 2035[IV]. The process generated strong international interest: 86 offers were received from 9 companies, including three new foreign players that provided competition, innovation and savings of more than 16% compared to previous processes. In addition, the electrification process of the System has managed to attract investment of more than 2.8 billion dollars, including buses, electroterminals, charging infrastructure and the added value associated with the labor market with gender policies and the incorporation of women drivers. This confirms Santiago as a learning and expansion platform for the region.

Moving forward, the new tender for fleet provision and operation launched in the second half of 2025[X] will give continuity to the provision model, reinforcing regulatory innovations that ensure quality and sustainability. These include: maintenance certification by an independent third party, the obligation of supply contracts with minimum contents between dealers and suppliers, and the guarantee of battery autonomy. In addition, the System will finance bus procurement fees, which include maintenance certification costs and other elements that ensure a useful life of at least 10 years. The price of these quotas will be a key factor in the award of bids.

3. Results: social, environmental and economic impacts

Electromobility in Santiago de Chile already shows measurable results. In 2023, PM2.5 emissions from the RED System were reduced to 22.5 tons per year, while CO_2eq emissions fell to 346,103 tons per year. Compared to 2019 (before the pandemic), these figures represent a 52.8% reduction in fine particulate matter and 22.3% in greenhouse gases, consolidating Santiago's public transport system as a benchmark in sustainability and energy efficiency.

Graph 2: Atmospheric emissions 2018-2023 (Ton/year)



Source: 1st Metropolitan Public Transport Directory Electromobility Report i, as of the Sixth Annual Emissions Report of the RED System 2024 [XI]

This impact is also explained by a structural change in the energy matrix of the system. Between 2018 and 2023, diesel consumption fell by 33.7%, while electricity demand increased fivefold, reaching more than 100 million kWh per year. This transition not only decreases dependence on fossil fuels, but also drives a sustained drop in the intensity of CO2eq emissions (grams of CO_2 equivalent per kilometer traveled) showing a decreasing and constant trend from 1,079 gCO_2eq/km in 2018 to 854 gCO_2eq/km in 2023.

Regarding noise, one of the most notable benefits of electromobility is the significant reduction in acoustic pollution: electric buses emit, on average, between 5 and 6 decibels (dB(A)) less than a diesel bus, which corresponds to a 68% to 75% reduction in acoustic energy generated[XII] .

Studies have also shown significant improvements in the interior noise levels of electric vehicles. Passengers experience quieter and more comfortable journeys (33% less acoustic energy), while drivers perceive a considerable reduction in noise-induced fatigue . In the driver's cabin, where noise is recognized as a source of work stress, measurements show a 2.7 dB(A) lower drop than in diesel buses, which favors occupational health and increases the perception of safety behind the wheel.

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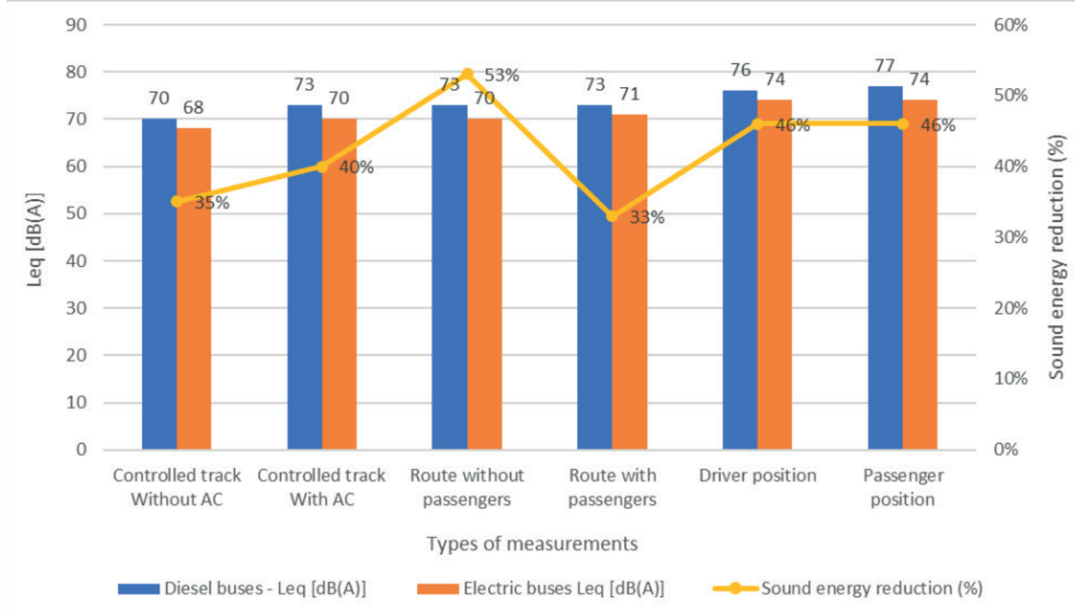
Graph 3: Average Leq [dB(A)] noise emission level recorded inside diesel and electric buses and their sound energy reduction in percentage (%) in the different types of measurements.



Source: 1st Metropolitan Public Transport Directory Electromobility Report [I].

Measurements carried out in collaboration with the Noise Monitoring Network of the Ministry of Environment of Chile confirm this trend. On the Alameda axis, Santiago's most important transport corridor, a 44% reduction in noise during peak hours was recorded following the introduction of electric buses. This pattern is repeated in other monitoring points distributed in the city, evidencing a sustained and widespread effect in the reduction of urban acoustic pollution, which translates into healthier and more livable urban environments..

Table 1: Noise levels in decibels (dBA) in Noise Monitoring Stations and distribution of bus shipments by technology.

Monitoring Stations	Date		Noise levels in decibels (dBA)		Distribution of buses according to technology in circulation in the axis			
					DIESEL	ELECTRIC	DIESEL	ELECTRIC
	Day	Year	8:00 to 9:00	19:00 - 20:00	8:00 to 9:00		19:00 - 20:00	
Alameda (Height N°924)	08/13/2019	2019	73.5	73.7	88%	12%	86%	**14%**
	08-17-2023	2023	71	71.5	66%	34%	64%	**36%**
	Differences (dBA)		**-2.5**	**-2.2**				
	Percentage change in acoustic energy		**-44%**	**-40%**				
San Miguel (Santa Rosa N°3453.)	09/23/2020	2020	67.9	66.6	100%	0%	100%	**0%**
	09/12/2023	2023	65.3	64,7	68%	32%	73%	**27%**
	Differences (dBA)		**-2.6**	**-1.9**				
	Percentage change in acoustic energy		**45%**	**35%**				
La Florida (Walker Martinez N°300-380)	11/09/2022	2022	65.7	66,1	100%	0%	100%	**0%**
	11-14-2023	2023	66.5	65.6	100%	0%	100%	**0%**
	Differences (dBA)		**0.8**	**-0.5**				
	Percentage change in acoustic energy		**20%**	**-11%**				

Source: 1st Metropolitan Public Transport Directory Electromobility Report [1].

From a service perspective, electromobility has transformed the daily experience of millions of users: the new buses incorporate air conditioning, WiFi connectivity, USB ports, universal accessibility and safer cabins for drivers.

These improvements have raised the perception of quality of the system, with surveys showing that 79% of users consider that electric buses improve the image of Santiago, while 84% declare to be proud of the system. Among the residents of electroterminals, 89% recognize electromobility as a sign of modernity and innovation that revitalizes their neighborhoods.

On the social level, electromobility has also opened up new spaces for labour inclusion. Today, 11.2% of the driving staff in the RED System are women (2,156), a milestone in a historically masculinized sector, a process that has involved an investment and capture of added value in human capital of more than 135 million dollars. To consolidate this progress, the 2023 Tender incorporates for the first time the principle of gender equity, setting goals of 12% of women in the second year of concession and 18% in the fifth year.

Likewise, the concessionaires, through the installation of the transformation and the creation of new electroterminals, have created formal jobs in vulnerable sectors, bringing stable and quality job opportunities to local communities. This shift is deeply inspiring: Sustainable mobility in Santiago not only displaces people, it also opens pathways to greater equity.

That positive perception is reflected in other actors in the ecosystem. Surveys of stakeholders (from operators to suppliers, neighbours and social organisations) confirm that electromobility is seen as a symbol of technological innovation and urban progress. Santiago is no longer just the capital of Chile: it is also a living laboratory of how sustainable mobility can transform cities.

Economically, the financial scheme allowed significant savings in tenders, strengthened investor confidence and reduced risks. The entry of new international actors with experience in electromobility enriched the local ecosystem, generating a virtuous circle of competition and innovation, attracting investment at a financial cost consistent with risk mitigation.

In parallel, the technological evolution and the scale achieved in the market have drastically reduced the cost gap between electric and diesel buses. While in 2020 an electric bus cost almost twice as much as a conventional one (1.8 times), today that difference has practically disappeared: the ratio is just 1.07. Added to this is that energy yields are considerably higher, going from an average cost of 0.20 US dollars per kilometer traveled in a diesel bus to just 0.11 US dollars per kilometer in an electric bus of the same size, which further strengthens its economic competitiveness.

This change marks a turning point, as it makes electromobility an alternative that is not only environmentally superior, but also competitive in economic terms, opening the door to an irreversible massification.

4. Projections to 2025 and 2026

The year 2025 will mark a turning point. It is expected that more than two thirds of the Mobility NETWORK fleet will be electric, consolidating Santiago as the city with the most electric buses outside China. The entry of 1,800 new electric buses will improve the coverage and quality of service, especially in peripheral communes, extending the benefits of electromobility to territories that had previously been marginalized.

In 2026, the system will face a new stage of tenders that will maintain the bus and infrastructure provision model, with emphasis on energy efficiency standards, battery autonomy and maintenance certification. This will ensure the sustainability of the model and give continuity to a state policy that transcends governments.

In the energy dimension, the challenge will be to expand and diversify the charging infrastructure, articulating competitive supply contracts with generators and distributors, integrating intelligent management and storage technologies, and promoting the use of renewable energies. Likewise, it seeks to replicate the experience of Santiago in other regions of Chile, accelerating the decentralization of electromobility and extending its benefits throughout the country.

5. Santiago as a benchmark for Latin America

Santiago's experience offers key lessons for the region, especially the importance of having a solid legal framework, financial mechanisms that reduce risks, well-designed subsidies, flexible contracts that promote competition and effective articulation with the energy sector. But, above all, it shows that electromobility is more than a technological solution: it is a cultural change that improves people's daily lives, strengthens the social fabric and generates citizen pride.

For Latin America, where the challenges of congestion, pollution, and urban inequality are shared, Santiago de Chile's story is inspiring and a clear sign that the transition to electric and sustainable public transport is not only possible, but also desirable and replicable, provided that it combines political vision, institutional innovation, and citizen engagement.

The challenge ahead will be to consolidate this model as a State policy, allowing Chile to reach its carbon neutrality goal in 2050 and for more cities in the region to find Santiago a close and inspiring reference on their own path towards sustainable mobility.

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Ministry of Energy of Chile and AgenciaSE: Programs Driving an Electromobility Strategy with Tangible Results

Sustainable development in Chile represents one of the essential pillars for achieving carbon neutrality by 2050. According to the 2023 National Energy Balance (BNE), that year the transport sector accounted for 33.3% of total energy demand, supplied 98.9% by fossil fuels, resulting in a high level of greenhouse gas (GHG) emissions. Furthermore, 85.3% of the sector's energy consumption came from land transport.

In response to this scenario, the country has established a solid roadmap to transform energy use in transport, focusing on greater energy efficiency, the reduction of GHG emissions, and the strengthening of energy security.

The National Electromobility Strategy, promoted by the Ministry of Energy, sets a clear goal: to ensure that everyone can access the benefits of zero-emission sustainable transport. In this way, the strategy aims not only to advance sustainability but also to improve quality of life through environmentally friendly technologies.

This effort is aligned with the Electromobility Roadmap, which outlines concrete actions through 2026 in areas such as charging infrastructure, public transport, training and capacity building, and regulatory frameworks. The main objective is to accelerate the adoption of electric vehicles and create conditions for their widespread use, consolidating a reliable and robust ecosystem.

To achieve these energy transition goals through sustainable mobility, the various actors within the ecosystem have consistently worked collaboratively across the public and private sectors since the past decade.

One notable instance of this collaboration is the 2025 Public-Private Electromobility Agreement, which currently involves over 170 stakeholders. This initiative has enabled the coordination of resources and the promotion of investments in infrastructure, vehicle replacement, workforce training, and cooperative networks.

Within this collaborative framework, various initiatives promoted by the Ministry of Energy of Chile have been consolidated and implemented by the Energy Sustainability Agency (AgenciaSE), an institution established by law to carry out public energy policies.

With the aim of promoting and supporting electromobility in fleets, the Electromobility Accelerator has been held since 2019. Forty-six public and private organizations have participated, taking their first steps toward electromobility with technical guidance to develop a roadmap tailored to each specific case.

A flagship initiative is Mi Taxi Eléctrico, a program designed to transform the public transport fleet by replacing combustion vehicles with 100% electric cars.

The target segment focuses on light passenger transport vehicles, including taxis and shared taxis across different service categories.

Implementation is carried out through co-financing for the purchase of an electric vehicle, complimentary installation of a home charging station for the taxi driver, and ongoing technical support to ensure a smooth transition to electromobility.

In 2021, the first edition of the Mi Taxi Eléctrico (MTE) program replaced 50 combustion vehicles operating as standard taxis in the Metropolitan

Region.

Subsequently, the second edition of the MTE program replaced 93 vehicles (standard and executive taxis, as well as urban shared taxis) across the regions of Valparaíso, Metropolitan, La Araucanía, Biobío, and Los Ríos.

Currently, the third edition of the program is being implemented in the regions of Antofagasta, Atacama, O'Higgins, Biobío, and Metropolitan, having delivered 205 vehicles between 2024 and 2025.

Building on these programs, the expansion of the electric vehicle charging network across the country has been strengthened through the Más Carga Rápida initiative, implemented with international funding from GIZ and GEF7. As a result of this initiative, all regions of Chile now have at least one fast-charging station for electric vehicles.

Additionally, with funding from GEF7, a complementary initiative to Mi Taxi Eléctrico was carried out, called Más Transporte Eléctrico, aimed at providing electric shared taxis in the regions of Antofagasta, Maule, and Los Lagos. This program implemented a pilot scheme for a new co-financing model for 30 beneficiaries and developed several workforce training sessions in Santiago and other regions.

As a key element for the success of these programs, the development of specialized human capital has also been strengthened:

- 60 people trained in safety and accident intervention involving electric vehicles..
- 25 new electric vehicle workshops were established.
- 171 people trained in electric vehicle maintenance and diagnostics.
- 182 electrical installers trained in residential charging infrastructure.

These are some of the most notable initiatives developed by the Ministry of Energy and AgenciaSE. The results achieved demonstrate that electromobility represents an extraordinary opportunity for Chile.

With a defined strategy, a clear roadmap, and the commitment of all sectors, the country is steadily advancing toward regional leadership in sustainable mobility. This gradual and collaborative implementation model lays the foundation for a comprehensive energy transformation of the transport sector, making a significant contribution to the country's carbon neutrality goals.

Acknowledgements

This book has been prepared with the collaboration of the following institutions:

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Gobierno de Chile | Ministerio del Medio Ambiente | Ministerio de Transportes y Telecomunicaciones | Agencia Chilena de Cooperación Internacional para el Desarrollo

CAF BANCO DE DESARROLLO DE AMÉRICA LATINA Y EL CARIBE

gef fondo para el medio ambiente mundial INVERTIMOS EN NUESTRO PLANETA

CLETS APOYO A LA ESTRATEGIA CHILENA DE TRANSPORTE PÚBLICO SOSTENIBLE

With the support of:

Agencia de Sostenibilidad Energética

ALADDA Asociación Latinoamericana de Distribuidores de Automotores

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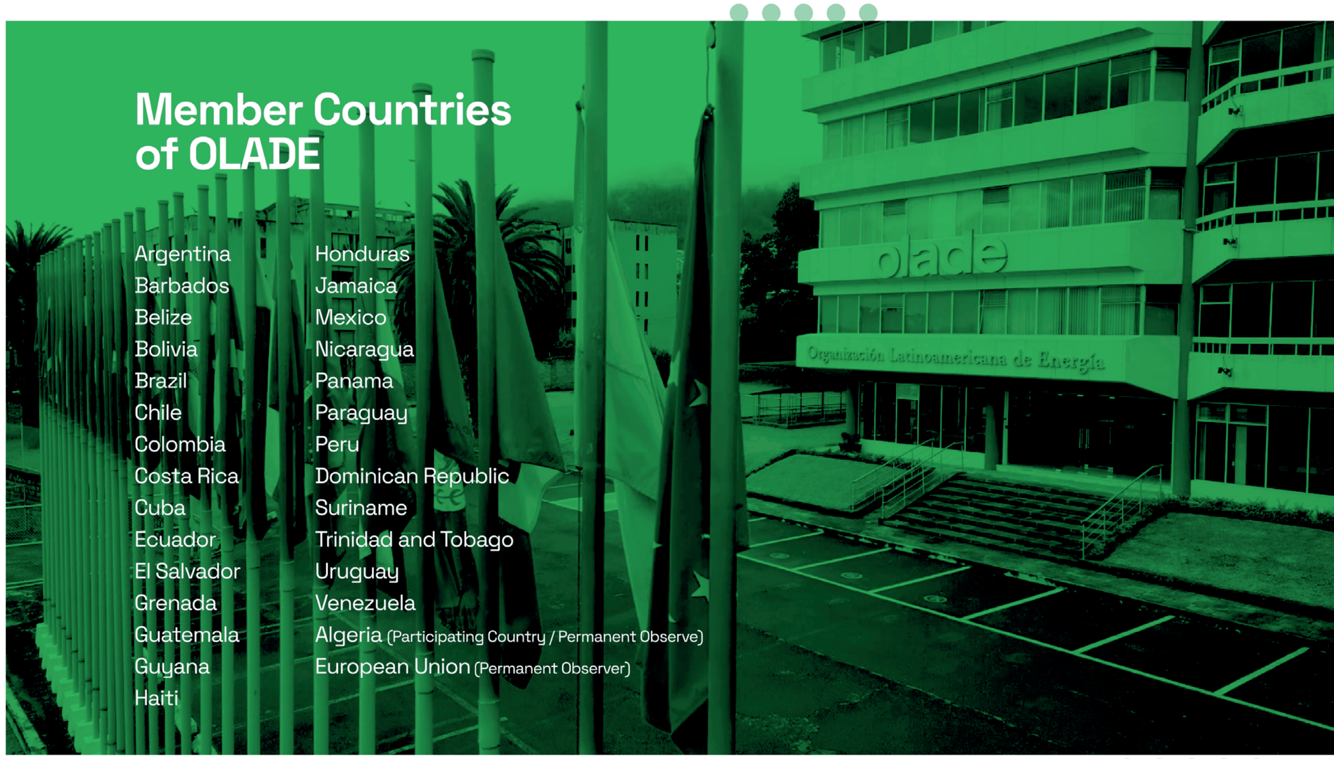

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