09

TECHNICAL NOTE
JUNE 2025

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

TECHNICAL NOTE Nº 9

PROSPECTS FOR LOW-EMISSION HYDROGEN IN LATIN AMERICA AND THE CARIBBEAN

Energy Join us

This document was prepared under the guidance of
Latin American Energy Organization
(OLADE)

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Methodological Note:

The Technical Note, “Prospects for low-emission hydrogen in Latin America and the Caribbean”, presents an analysis of the global landscape for this energy vector, with a particular emphasis on the regional context. It explores national objectives for the development of low-emission hydrogen in the short, medium and long term.

The results presented in this document are based on an analysis of the hydrogen market development strategies across various countries in Latin America and the Caribbean, within the framework of several activities related to this energy vector, led by the Latin America Energy Organization (OLADE). These efforts aim to strengthen the region’s capacity to promote the implementation of low-emission hydrogen projects.

The information presented corresponds to a regional comparison of the prospects for low-emission hydrogen on areas such as: I) Cost, II) Production, III) electrolysis capacity and renewable energy, IV) exports, V) investments, VI) job creation, among other topics.

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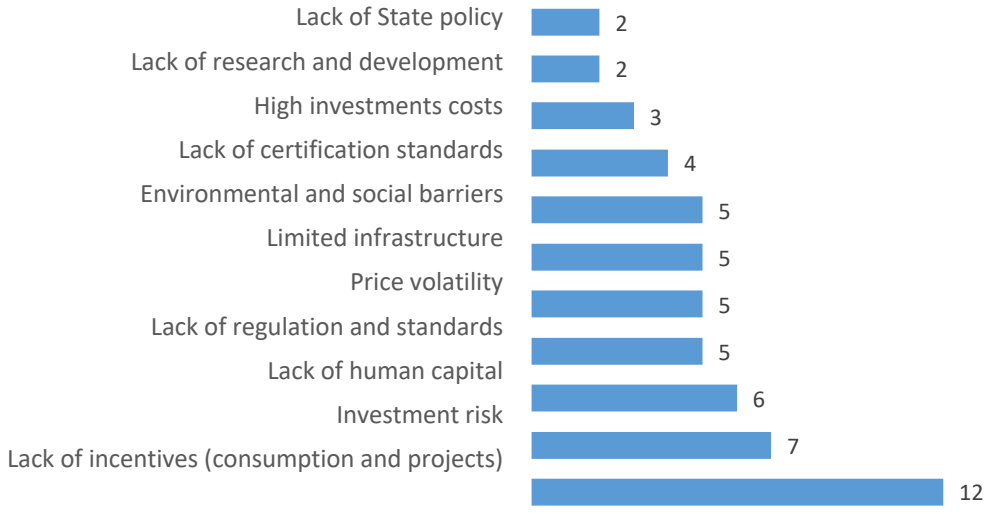
1. INTRODUCTION

Low-emission hydrogen is considered as a key energy vector for advancing the global energy transition, provided that several challenges are addressed to enable its integration in the energy matrix of countries.

According to the national strategies for developing the low-emission hydrogen market of Latin American and Caribbean (LAC) countries, several common challenges must be addressed, highlighting the lack of incentives for consumption and project development; market risks; the lack of trained human capital, as well as regulation and standards, without neglecting the importance of certification standards (Figure 1).

Figure 1. Barriers for the development of low-emission hydrogen market in LAC



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

According to the International Energy Agency's *World Energy Outlook 2024*, achieving net-zero emissions by 2050 will require global production of approximately 65 Mt of low-emission hydrogen by 2030. However, based on currently planned projects globally, projected production is expected to reach only between 26Mt and 49 Mt.

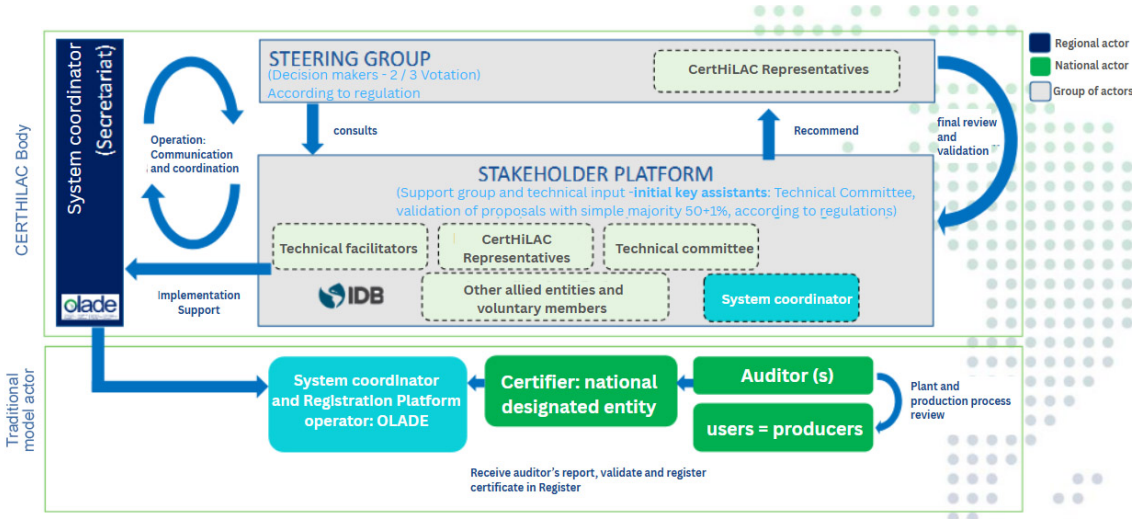
Therefore, significant efforts are required to overcome the barriers that hinder the sustainable development of low-emission hydrogen. In this regard, the Latin American Energy Organization is implementing the following initiatives aimed to promote this energy vector in the region:

- Strengthening Latin America's capacity to comply with international certification standards for low- or zero-emission hydrogen and its derivatives, for export purposes. This project, carried out in partnership with the European Union, the Chilean Agency for International Development Cooperation (AGCID) and OLADE, aims to develop a roadmap that will allow the countries in the region to obtain certification for accessing international markets—particularly the European market. The initiative is based on the study of four pilot countries (Argentina, Chile, Colombia and Panama).
- Strengthening human capital and national research systems in the renewable hydrogen sector in the Southern Cone of America countries. This project is supported by the Spanish Cooperation (ARAUCLIMA Program) and OLADE, and the Centre for Energy, Environmental and Technological Research (CIEMAT), the National Hydrogen Centre and the Higher Centre for Scientific Research (CSIC) as partners. Within this framework, a comparative diagnosis will be conducted of existing training, education or research initiatives in three Southern Cone of America countries (Argentina, Chile and Uruguay), in the different stages of the renewable hydrogen value chain.
- CertHiLAC, an initiative of the Inter-American Development Bank (IDB), in collaboration with OLADE and the participation of several countries. It aims to establish a certification system of clean, low-carbon hydrogen for Latin America and the Caribbean, aimed to guarantee the traceability of hydrogen, to facilitate the export of this product from the region. The initiative also promotes the creation of favorable regulatory frameworks, encourages investment, and support knowledge exchange.

  The pillars established for CertHiLAC emphasize a voluntary, flexible and easy to implement certification process. At present,

the regional governance scheme of CertHiLAC has already been defined (Figure 2).

Figure 2. CertHiLAC Regional Governance Scheme



Source: CertHiLAC

In this manner, through the joint work of LAC countries, hydrogen can effectively contribute to climate change mitigation, the achievement of the Sustainable Development Goals and the commitments of the Paris Agenda

2. GLOBAL HYDROGEN SITUATION

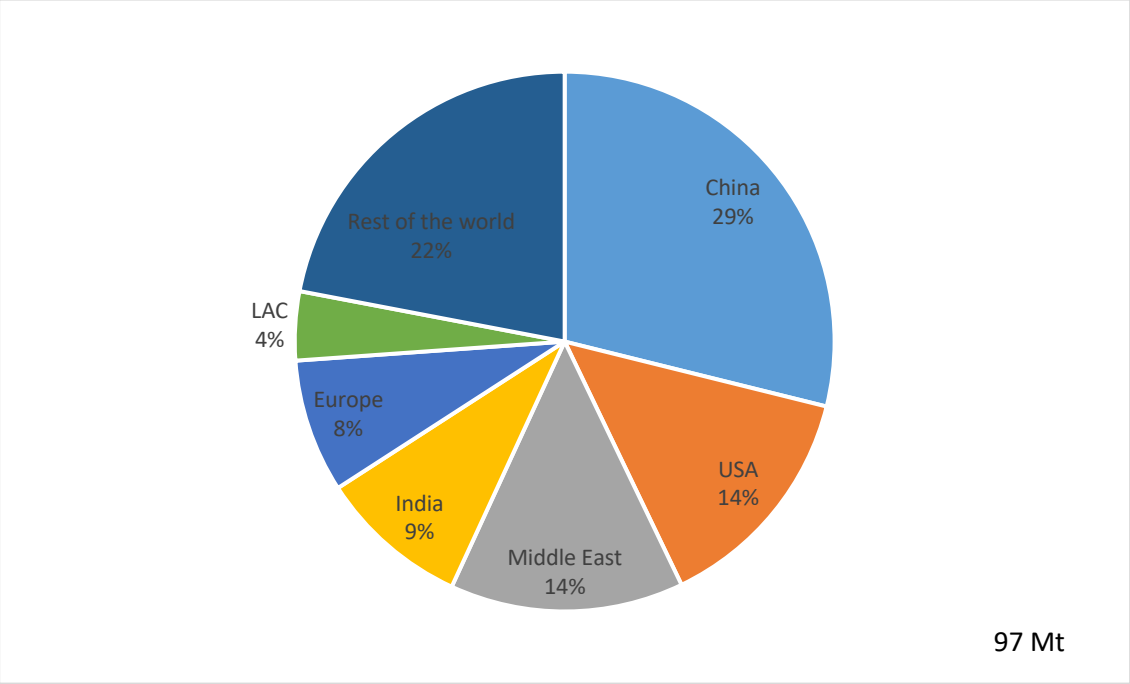
Global demand for hydrogen has been increasing over time, reaching 97 million tons (Mt) in 2023, according to the International Energy Agency's *Global Hydrogen Review 2024*. Nevertheless, the production of low-emission hydrogen (1 Mt in 2023) remains marginal when compared to that coming from fossil fuels without mitigation mechanisms.

In 2023, Low-emission hydrogen was primarily produced from fossil fuels with carbon capture, use and storage (CCUS) technology, while

production via electrolysis reached only 100 thousand tons (kt)[1]. Despite the low participation of hydrogen obtained from water electrolysis, this technology has experienced significant growth in recent years. By 2023, the installed capacity of electrolyzers reached 1.4 GW. Notably, that same year, China put into operation the largest electrolyzer project in the world, with a capacity of 260 MW (Sinopec's Kuqa Plant).

Currently, China is the country with the highest demand for hydrogen globally (approximately 30% of the total), followed by the United States and the Middle East (each with 14%), India (9%) and Europe (8%). Notably, Latin America and the Caribbean represented 4% of total hydrogen demand in 2023 (Figure 3).

Figure 3. Global hydrogen demand by region

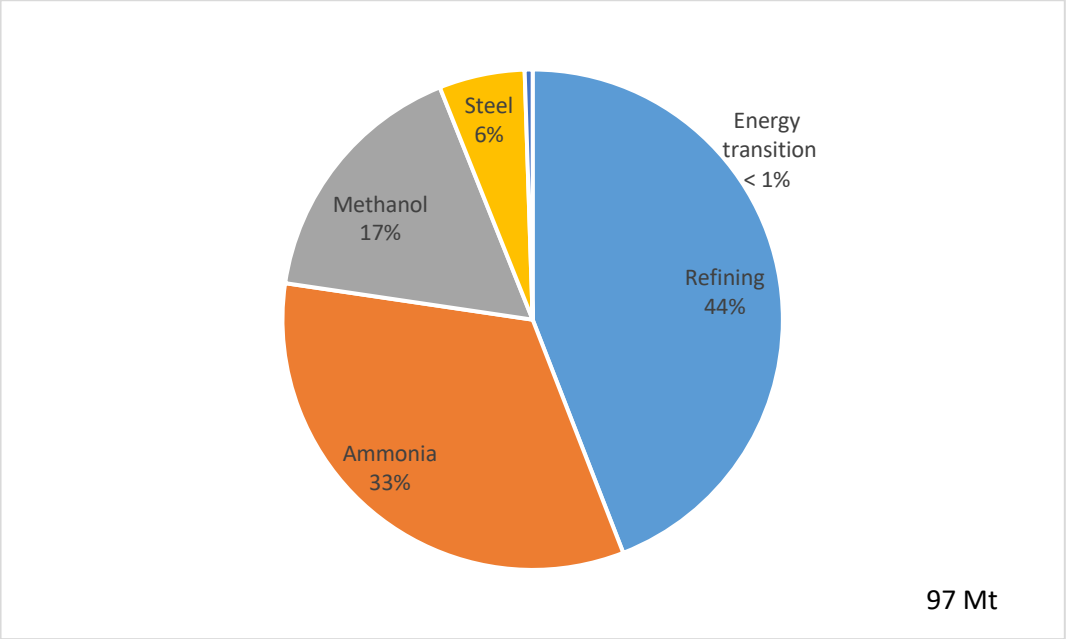


Source: Author's elaboration based on information from the International Energy Agency.

[1] Electrolysis from renewable energy enables the separation of hydrogen from water with zero emissions, making it the cleanest method (green hydrogen). CCUS technology captures and stores carbon from the production of hydrogen from fossil fuels, significantly reducing greenhouse gas emissions, but not 100%

At present, virtually all hydrogen demand is concentrated in traditional sectors, specifically in refining, as well as in the chemical and steel manufacturing industries (Figure 4).

Figure 4. Global hydrogen demand by sector



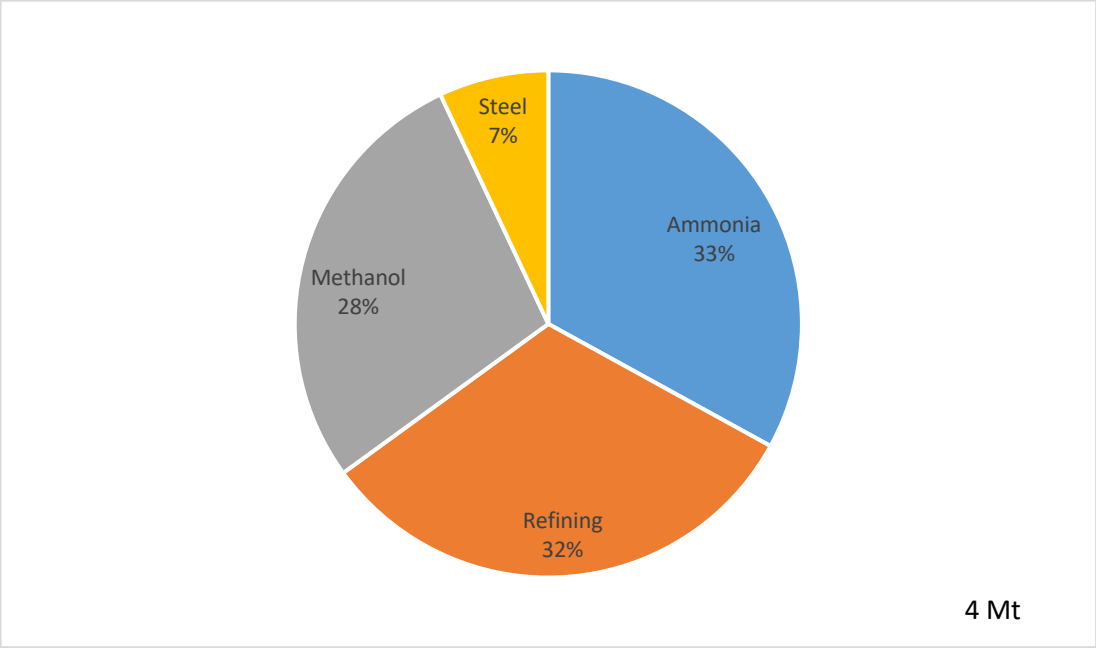
Source: Author's elaboration based on information from the International Energy Agency.

On the other hand, the use of low-emission hydrogen in fundamental sectors to the energy transition remains marginal, despite the notable increase in its production in recent years. This is why the use of hydrogen has not yet delivered meaningful benefits in terms of climate change mitigation. On the contrary, it has contributed to an increase in global emissions associated with this product, which reached 920 Mt of CO_2 in 2023.

3. HYDROGEN SITUATION IN LATIN AMERICA AND THE CARIBBEAN

In 2023, Latin America and the Caribbean demanded about 4 Mt of hydrogen, primarily in chemical production and refining, in line with global trend. Notably, around 90% of the hydrogen was produced with natural gas steam reforming, resulting in over 30 Mt CO_2 emitted (Figure 5).

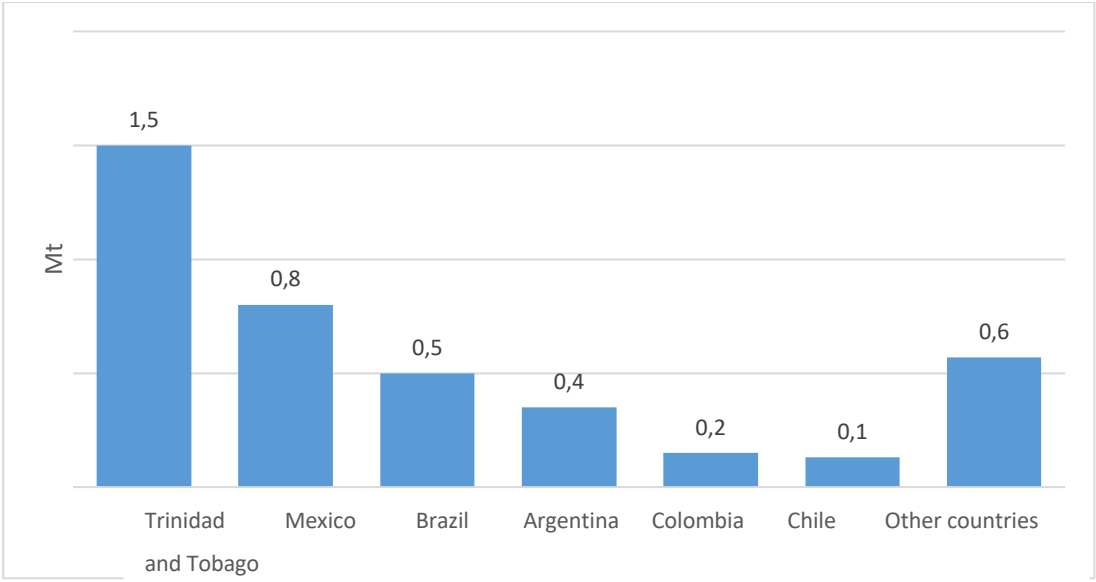
Figure 5. Global hydrogen demand by sector in Latin America and the Caribbean - 2023



Source: Author's elaboration based on information from the International Energy Agency.

Trinidad and Tobago is the country with the highest demand for hydrogen in the region (1.5 Mt in 2023), primarily driven by its chemical industry for the export of ammonia and methanol. It is followed by Mexico, Brazil, Argentina, Colombia and Chile (Figure 6).

Figure 6. Hydrogen demand by country in Latin America and the Caribbean

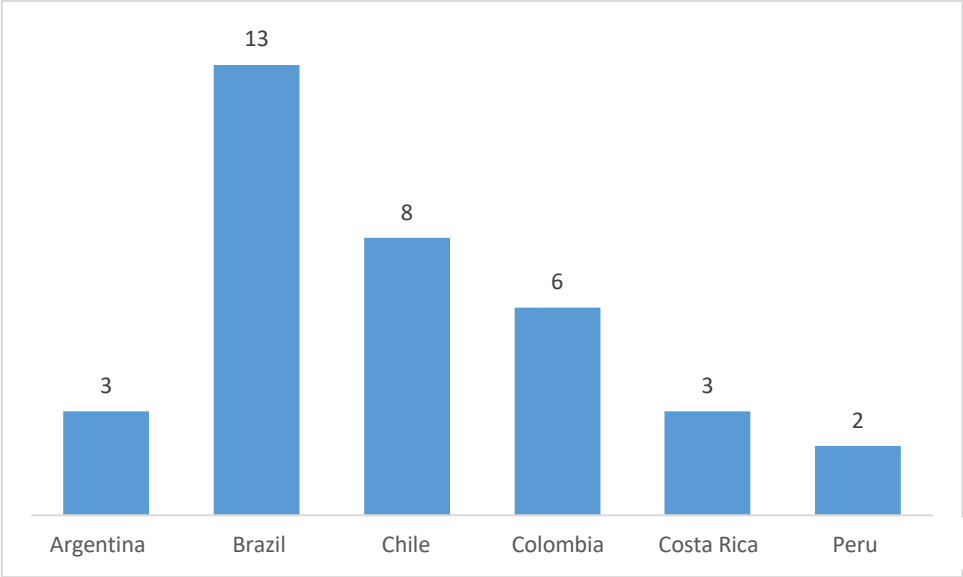


Source: Author's elaboration based on information from the International Energy Agency.

3.1 Hydrogen projects in operation

According to information from OLADE, IEA and H2LAC, Argentina, Brazil, Chile, Colombia, Costa Rica and Peru already have low-emission hydrogen projects in operation (Figure 7)

Figure 7. Number of hydrogen projects in operation by country

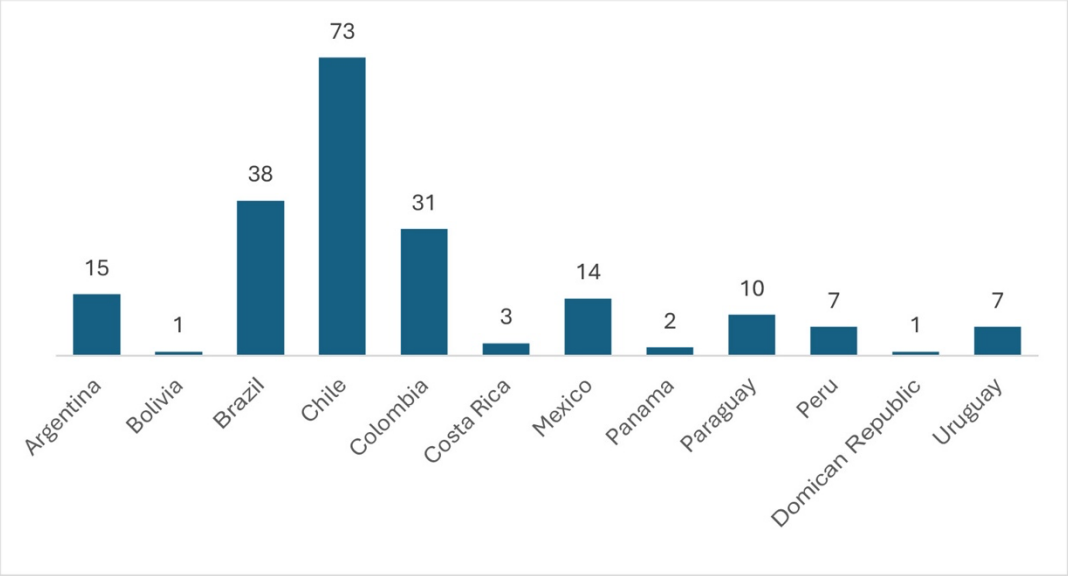


Source: Author's elaboration based on information from the International Energy Agency.

3.2 Future projects

According to information from OLADE, IEA and H2lac, Latin America and the Caribbean plans to implement over 200 low-emission hydrogen projects, with Chile, Brazil and Colombia as the main countries to implement them. This reflects the region's potential to contribute to the development of this market, which is crucial for global decarbonization (Figure 8).

Figure 8. Number of hydrogen projects planned by country

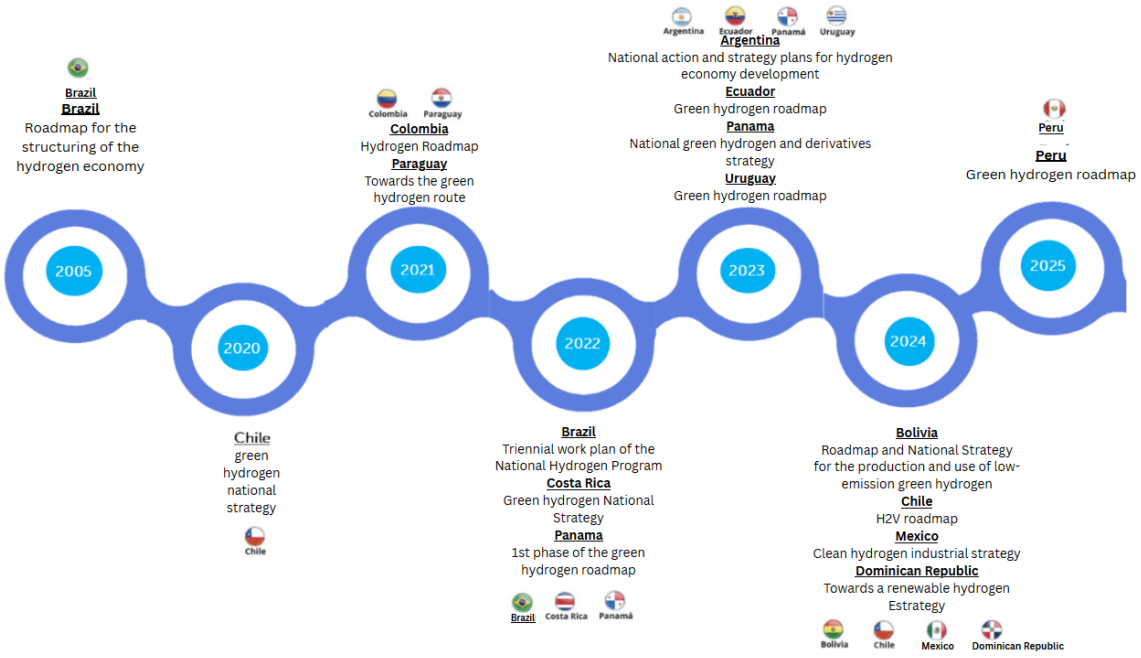


Source: Author's elaboration based on information from OLADE, the International Energy Agency and H2lac.

4. NATIONAL STRATEGIES FOR THE DEVELOPMENT OF LOW-EMISSION HYDROGEN IN LATIN AMERICA AND THE CARIBBEAN

Latin America and the Caribbean countries have been formulating strategies for the development of the hydrogen industry since 2005. Nevertheless, over the past 5 years, most countries have established clearer strategic lines, actions and goals to be achieved in the coming years (Figure 9).

Figure 9. National Hydrogen Strategies in Latin America and the Caribbean timeline



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

The following section provides a general analysis of the strategies and action plans that countries in the region aim to implement to support the development of the low-emission hydrogen industry.

Argentina, through its strategy, has outlined the promotion of technological and productive development across the hydrogen value chain. The country aims to produce low-emissions based on different technologies—including renewable sources, nuclear power, and fossil fuels with carbon capture—as well as the deployment of the economy of this product through both domestic market and export.

The guidelines of Argentina's action plan are structured around the following pillars: regulatory enablers, supplier development, training and employment, infrastructure, and demand promotion

Bolivia has planned to implement lines of work focused on the efficient production and distribution of hydrogen, the promotion of domestic consumption and exports, competitive levelized cost and the institutional strengthening.

The action plan contemplates: efficient production and distribution, promotion of domestic consumption and exports, competitive levelized cost, and institutional strengthening.

Brazil aims to develop and consolidate the hydrogen market by promoting international insertion, positioning hydrogen as a priority area for investments, research and development. The country also aims to diversify its energy sources available for the production of this energy vector.

Brazil’s action plan includes specific measures to design low-emission hydrogen pilot plants in all regions. It also aims to consolidate the country as the most competitive producer of this product globally, and to stablish low-carbon hydrogen hubs.

Chile has proposed strategic guidelines for the development, production and export of hydrogen, with a focus on promoting decarbonization hard-to-electrify

sectors. It also aims to attract investment and generating employment in the country.

Chile's action plan includes: governance and multi-stakeholder participation; information, dissemination and education; regulatory and normative framework; economic and financial incentives; human capital development; research, development and innovation; enabling infrastructure; territorial planning and land use; environmental sustainability; local development and shared value; integration with other productive sectors; domestic market and national demand; export and international positioning; security and risk management; monitoring and follow-up; communication and transparency; international cooperation; and adaptation to climate change.

Colombia

Colombia has established strategic guidelines for hydrogen development through its national roadmap, with a focus on decarbonization, industrial development, and exports. The strategy aims to: create a stable and competitive regulatory framework, develop financial incentives and hydrogen purchase mechanisms, expand transport and storage networks, and boost hydrogen research and development.

The action plan is structured in 3 phases: 1) laying the foundations for hydrogen (regulatory framework, pilots and certifications, and human capital); 2) enabling and boost the market through financial incentives, infrastructure deployment, and a cluster strategy; 3) hydrogen monitoring and expansion (market assessment, expansion into new sectors, and port infrastructure development).

Costa Rica

Costa Rica, through its strategy, outlines a clear vision and sets short-, medium- and long-term objectives for green hydrogen in the country. The strategy includes an analysis of strategic interventions, indicators and goals, while also identifying regulatory, technical, financial, talent and capacity gaps.

The action plan aims to decarbonize the transport and industrial sectors, develop national hub for technology and innovation in green hydrogen, and promote the export of this product to the world.

Ecuador

Ecuador's national strategy focuses on meeting the demand and future export of green hydrogen, while analyzing the risks of market development and identifying the State policies needed to achieve this objective. This strategy aims to address gaps in the following aspects: economic and market, technical and technological, infrastructure, socio-environmental and public policy.

Ecuador's planned actions are centered in: research, development and innovation; standards and regulations development; infrastructure implementation; and the pursuit of International Cooperation.

México

Mexico, through its clean hydrogen industrial strategy, has defined the bases for the sector's development, considering projects that generates low or zero emissions. The strategy emphasizes in the need of experts in this field, ensure the availability of technology for projects development, infrastructure conversion, improve tax incentives for companies, and stablish official Mexican regulations specifically for hydrogen.

Mexico's strategic actions, among others, aims to: promote all types of hydrogen production, to coordinate the conditions for the development of a national industry, to promote educational cooperation, to build the necessary regulatory and normative framework, to coordinate strategies to favor accelerated development, to lay the necessary financial – economic – technological foundations, to generate conditions of self-sustainability in relation to consumption and use, identify present and future infrastructure, and generate alliances with development finance institutions.

Panama's strategy proposes the strategic positioning of the country as a global route for hydrogen and its derivatives, enhancing its geographical location and infrastructure to supply renewable energy to the logistics, domestic, maritime, air and land transport sectors. Additionally, the strategy seeks to develop the necessary capacities to foster the establishment of an innovative market.

The actions to be followed are framed in: turning Panama into the Transformational Hub for green hydrogen; promoting an integrated regional market for green hydrogen and derivatives; promoting the domestic market; developing human capital and social acceptance to support this economy; advancing legislation, regulation and financing mechanisms; promoting the creation of the required infrastructure; and encourage governance and triangular dialogue for the development of this industry.

Paraguay, in its strategic vision for the energy use of hydrogen, highlights the country's potential advantages to develop this energy vector, largely due its abundant surplus of hydroelectricity.

Paraguay proposes the following actions: implement a hydrogen fleet evaluation program; develop pilot projects for the use of green hydrogen; and to stablish a national strategy for sustainable mobility that promotes the use of electric energy across various modalities, including electric vehicles, hybrids and hydrogen-powered transport.

The objective of **Peru's** strategy is to achieve a level of self-sufficiency in products related to green hydrogen in the country, aiming to: develop the national industry; replace dependence on foreign products; position this energy vector as a key lever for emission reduction and climate change mitigation; generate an export market; and contribute to economic diversification, socio-economic development and innovation.

Actions for the deployment of low-emission hydrogen include: the establishment of regulatory frameworks; the creation of market bases for supply, demand, certification and research; the promotion of industrial innovation; and the pursuit of export opportunities.

República Dominicana

The **Dominican Republic's** strategy sets objectives for the deployment of renewable hydrogen in the country, considering as pillars the Research, Development and Innovation; the establishment of a regulatory framework; the pursuit of international cooperation; and the deployment of infrastructure, with a focus on the transport and industrial sectors.

Among other actions, the strategy proposes: cooperation strengthening in universities, research centers and companies; promoting human resource training abroad; the creation of a regulatory framework for legal certainty and facilitates investment; formally defining hydrogen as an energy vector; creation of guarantee schemes; and development of infrastructure to support both the export of ammonia and other derivatives, as well as for transport and national industry.

Uruguay

Finally, **Uruguay** plans to develop regulatory and pilot projects to stimulate the national hydrogen market on a large scale, as well as the export market. This approach aims to enable accelerated growth of exports in the country.

Uruguay's action plan is structured in 3 phases: 1) development of regulations, development of initial pilot projects, and attraction of first export-scale projects; 2) national expansion, initiation of the first export-scale projects; and 3) large scale development of the domestic market alongside accelerated export growth.

5. PROSPECTS FOR HYDROGEN MARKET DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN

The development of hydrogen will enhance the possibility to maximize the use of renewable energy in Latin America and the Caribbean. The region has a high potential for electricity generation from renewable sources, including hydropower (676 GW), solar photovoltaic (4,800 GW) and wind (420 GW). This can encourage LAC's incursion into the hydrogen and derivatives chain, not only at a local level, but also as an important global player in exports.

Opportunities for the use of low-emission hydrogen in LAC vary by country. For example, the existing hydrogen demand from countries refineries could be supplied with hydrogen produced with low-emission technologies, without requiring technological changes. The mining sector in Latin America and the Caribbean could use low-emission hydrogen to decarbonize its operations, particularly in two main areas where direct electrification is challenging: explosives, and heavy machinery and trucks.

Other countries have the potential to shift the process of reducing coal-based iron ore producing a low-emission hydrogen-based hot briquetted iron. Likewise, the nitrogen-based fertilizer production industry in these countries could reduce the economic impacts of current external dependence, considering that 80% of LAC's demand comes from imports

It is also important to note that hydrogen in the region could guarantee greater flexibility and security of electricity systems, supporting greater participation of intermittent renewable sources. Additionally, the region's abundant bioenergy resource offers significant potential to increase countries capacity to produce low-emission hydrogen-derived fuels for aviation and maritime transport.

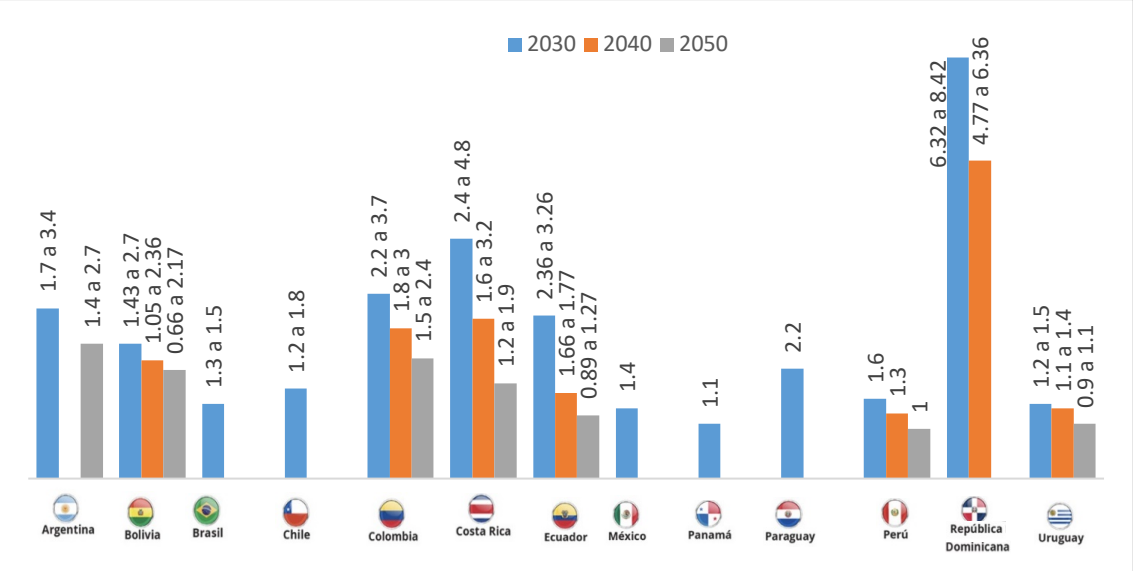
Thus, the countries of Latin America and the Caribbean have stablished clear objectives within their strategies for the development of the low-emission hydrogen market. A comparative analysis of some of the variables that will enable the achievement of these goals in the short (2030), medium (2040) and long term (2050) is presented below.

5.1 Hydrogen Costs

In the short term, Brazil, Chile, Mexico, Panama, Peru and Uruguay are projected to have the lowest hydrogen production costs, with ranges between 1.1 USD/kg and 1.6 USD/kg. Except for the Dominican Republic, which anticipates significantly higher costs (between 6.32 and 8.42 USD/kg), the rest of the countries analyzed have average cost ranges of up to 4.6 USD/kg

By 2050, Latin America and the Caribbean is projected to significantly reduce hydrogen production costs. Several countries that stand out, could have costs equal to or less than 1 USD/kg, including Bolivia (up to 0.66 USD/kg), Ecuador (up to 0.89 USD/kg), Peru (1 USD/kg) and Uruguay (up to 0.9 USD/kg) (Figure 10).

Figure 10. Levelized cost of hydrogen (USD/kg)



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

Despite the cost reduction planned by LAC countries for the future, it is important to note that companies such as Bloomberg[2] have forecast a potential cost increase—up to 3 times higher by 2050—due to the substantial investments required in the production of electrolyzers.

[2] Full article in https://www.bloomberg.com/news/articles/2024-12-23/green-hydrogen-prices-will-remain-stubbornly-high-for-decades

This must be taken into account when evaluating the objective of competitive costs for low-emission

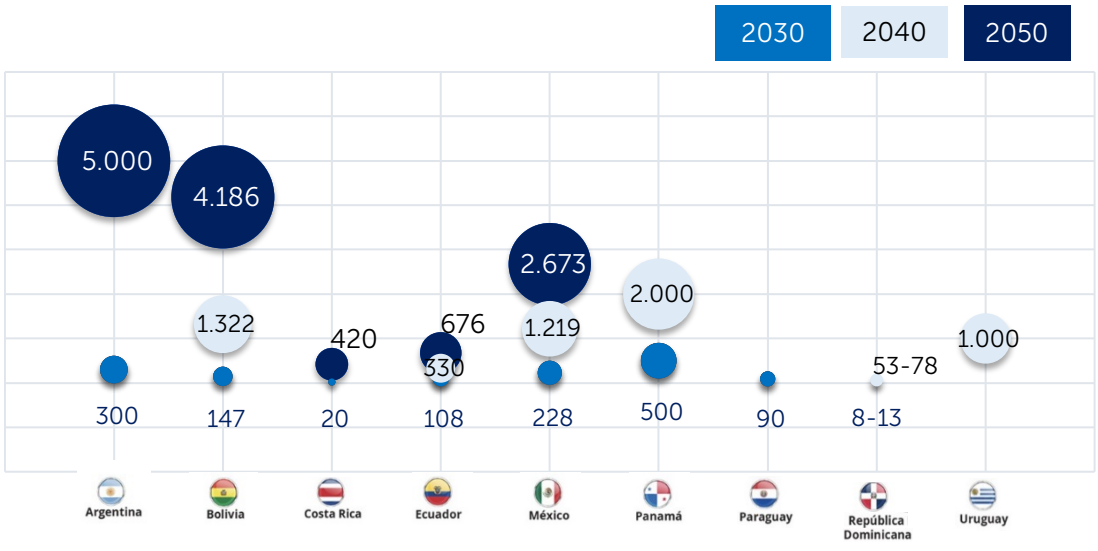
hydrogen versus other hydrogen production technologies, or even against other energy products.

5.2 Hydrogen production

Domestic hydrogen demand in the countries of the region is expected to emerge across various economic sectors, primarily in transportation, industrial processes, and electricity generation. Additionally, planning instruments in LAC, project the use of hydrogen as a raw material for the production of ammonia for the elaboration of fertilizers, and propose the target for exporting this product and/or its derivatives.

In the short term, the highest hydrogen production projections in the region could reach between 500 and 300 kt (Panama and Argentina), reaching up to 5,000 kt (Argentina) and 4,186 kt (Bolivia) in 2050. It is worth highlighting the technical potential for hydrogen production outlined in Brazil's strategy, with a 480 Mt per year in the long term, and Chile's strategy with a value that reaches 160 Mt per year (Figure 11).

Figure 11. Hydrogen production (kt)



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

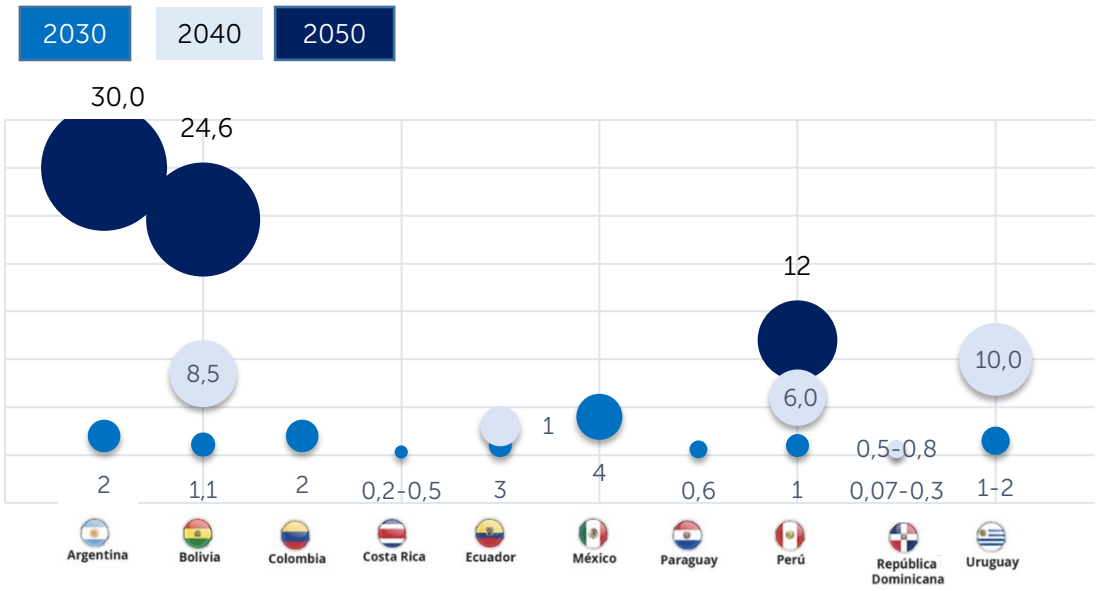
In this manner, and taking into account the projects announced by the countries, LAC could be expected to produce between 20 and 30 Mt of low-emission hydrogen by 2050.

5.3 Production sources and renewable energy requirements

Most of the low-emission projects announced in LAC are based on electrolysis with renewable sources. Nevertheless, other technologies— such as bioethanol reforming—are also being considered.

In this sense, several countries have projected the electrolysis capacity requirements for hydrogen production for different horizons. In the short term, Mexico (4 GW) and Colombia (between 1-3 GW) stand out with the largest projected electrolysis capacity, while other countries aim to install up to 1 GW (Figure 12).

Figure 12. Electrolysis capacity (GW)

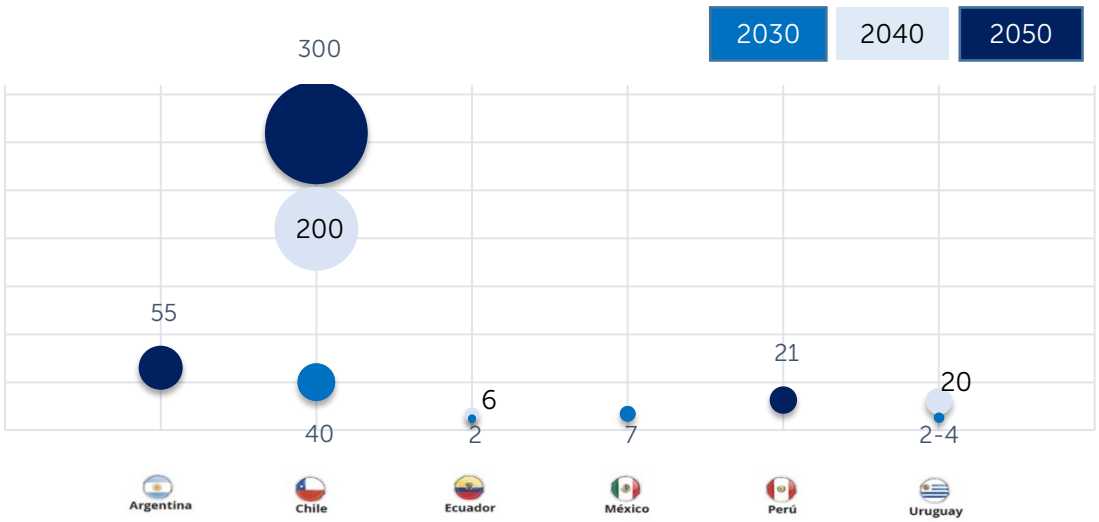


Source: Author's elaboration based on information from national strategies.

As the market matures, electrolysis capacity in LAC countries is expected to grow. So that by 2040, Uruguay, Bolivia, Peru and Ecuador project capacities of 10 GW, 8.5 GW, 6 GW and 3 GW, respectively. In the long term, Argentina, Bolivia and Peru plan to lead in the region with the highest electrolysis capacity in the region.

To supply the electricity demand required by electrolysis, several countries have reported their growth goals in installed capacity for electricity generation based on renewable energy. Chile stands out with the most ambitious goal, which aim to install 40 GW by 2030, 200 GW by 2040 and 300 GW by 2050. Uruguay also has a notable target in terms of electricity generation capacity to be installed by 2040, which reaches 20 GW, as well as Argentina's goal, which reaches 55 GW by 2050 (Figure 13).

Figure 13. Renewables capacity (GW)



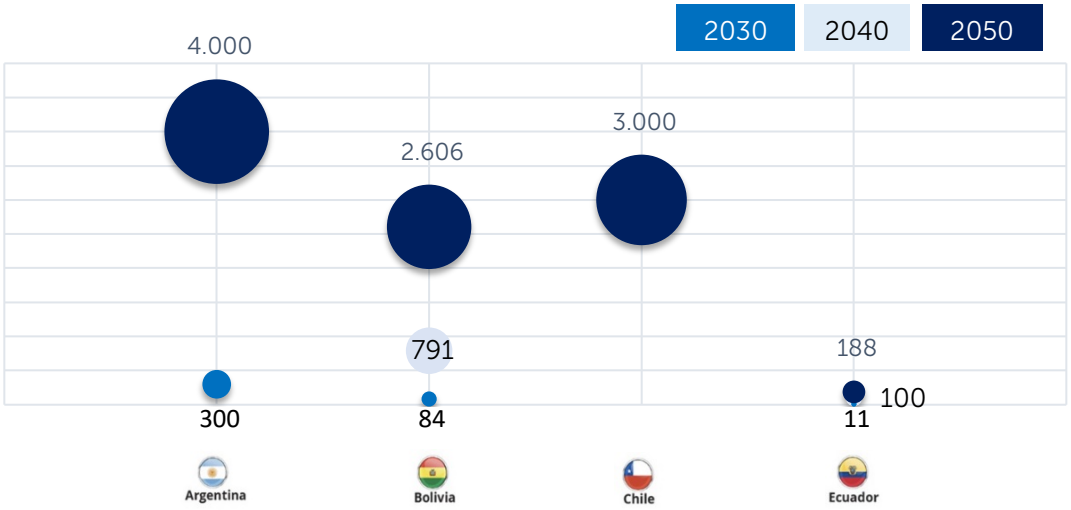
Source: Author's elaboration based on information from national strategies.

Considering the installation of projects targets and the regional projections for low-emission hydrogen production, by 2050 the installed electrolysis capacity could reach around 200 GW, while electricity generation capacity would reach more than 400 GW.

5.4 Hydrogen exports

Most countries in the region aim to produce hydrogen for export; nevertheless, only a few have established specific export targets. In the short term, Argentina and Bolivia have set goals to export 300 kt and 84 kt of hydrogen, respectively. by 2050, long term targets include Argentina with 4,000 kt, Bolivia with 2,606 kt, Chile with 3,000 kt and Ecuador with 188 kt (Figure 14).

Figure 14. Hydrogen exports (kt)

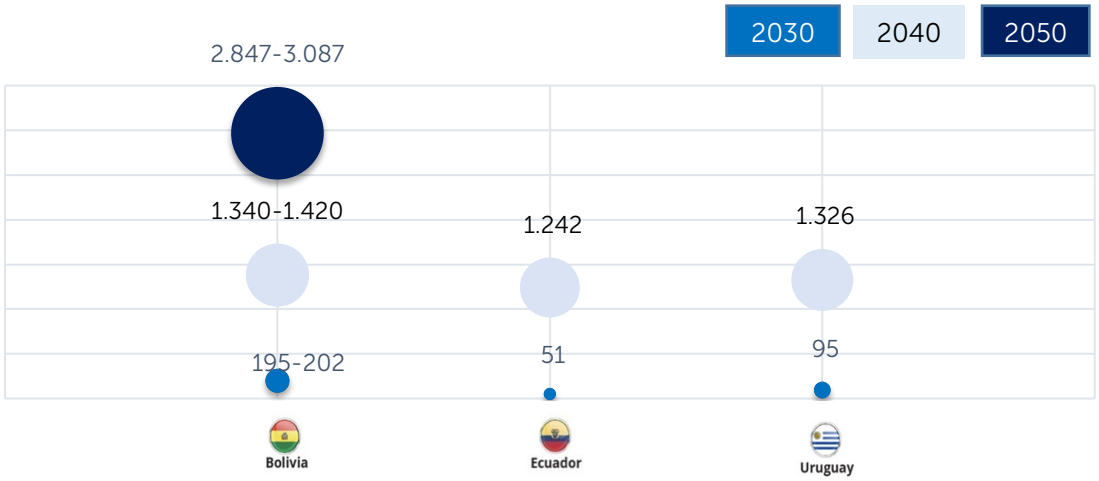


Source: Author's elaboration based on information from national strategies.

Along similar lines, some countries have highlighted the potential revenues from hydrogen exports. By 2050, Bolivia could earn revenues of approximately 3.000 MM USD, while Ecuador 1.242 MM USD by 2040.

On the other hand, Uruguay has set the goal of capturing 3.5% of the projected market by 2040. In economic terms, the country expects export revenues of 95 MM USD and 1,326 MM USD in the short and medium term, with aviation and maritime fuels expected to be the main products to be exported (Figure 15).

Figure 15. Export earnings (MM USD)



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

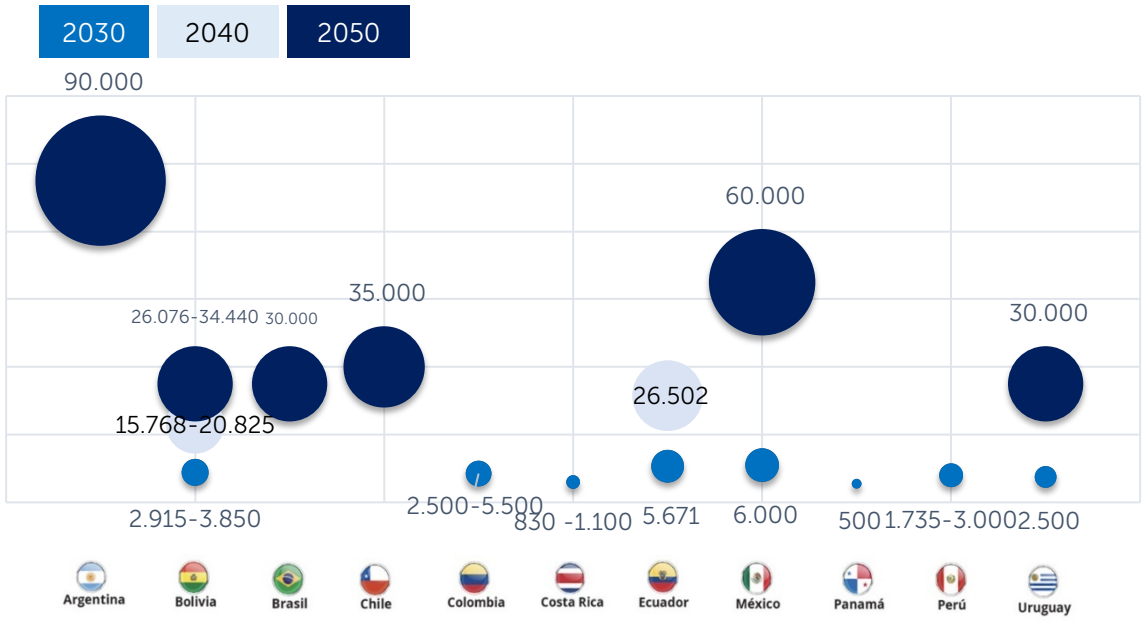
As shown, the international low-emission hydrogen market will be relevant for the region. expected exports could exceed 11 Mt, generating economic revenues equivalent of more than 13,000 MM USD by 2050.

5.5 Required investments

LAC countries foresee significant investments in both electrolysis infrastructure and electricity generation to support the development of the hydrogen market. In the short term, investments vary between 500 MM USD and 6,000 MM USD per country.

In the long term, Argentina projects the largest investment, reaching a value of 90,000 million USD, followed by Mexico with 60,000 million USD. Meanwhile, Chile, Brazil, Uruguay and Bolivia anticipate investment requirement of approximately 30,000 MM USD by 2050 (Figure 16).

Figure 16. Investments (MM USD)



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

With the contribution of the countries, cumulative investments in the region for the development of low-emission hydrogen projects could

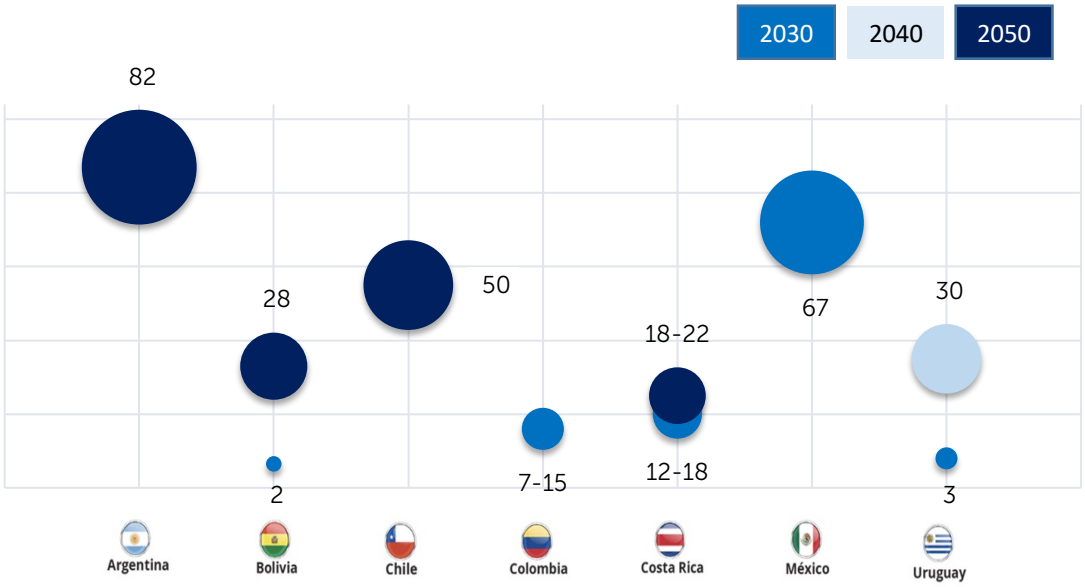
be expected to range between 200,000 MM USD and 300,000 MM USD by 2050.

5.6 Human capital

Several countries in the region have projected job creation linked to hydrogen production. Notably, Mexico has set the most ambitious short term employment target, with the potential to generate approximately 67,000 jobs. In the medium term (by 2040), Uruguay could generate 30,000 jobs, while in the long term, Argentina is projected to create 82,000 jobs related to this industry.

In this manner, the low-emission hydrogen industry could create approximately 350,000 jobs throughout the region in the long term (Figure 17).

Figure 17. Human capital (thousands of people)



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

6. CONCLUSION

In Latin America and the Caribbean, the development of hydrogen and its low-emission derivatives market, will enable the region to take advantage of its renewable energy potential. Sectors such as the mining, iron and steel, transportation and electricity generation industry in LAC, and fertilizer production industry, can benefit from this process.

It should not be forgotten that most countries aim to position the hydrogen produced and/or its derivatives in international markets. Nevertheless, achieving this will require overcoming several challenges.

The national strategies outlined in recent years by LAC countries set objectives to overcome the barriers that currently prevent the development of the low-emission hydrogen market. The creation of regulatory frameworks and certification schemes, the promotion of projects through incentives and the training of personnel are among the priority actions that must be addressed in the short term in the region.

Countries have projected a gradual reduction in the production costs of low-emission hydrogen over time. In addition, a substantial increase in installed capacity with renewable technologies—primarily photovoltaic and wind—is expected for the supply of electricity required in electrolysis for the development of the market. Together, these developments are poised to attract greater investment and create a significant number of jobs in LAC.

To achieve a global energy transition—including Latin American and Caribbean countries—it will be essential to promote greater participation of hydrogen and its low-emission derivatives in energy matrices. All this, since there is great potential for these products to contribute to the decarbonization of multiple economic sectors, providing flexibility and security to electricity systems, and deliver broad economic, social, and environmental benefits to the region.

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