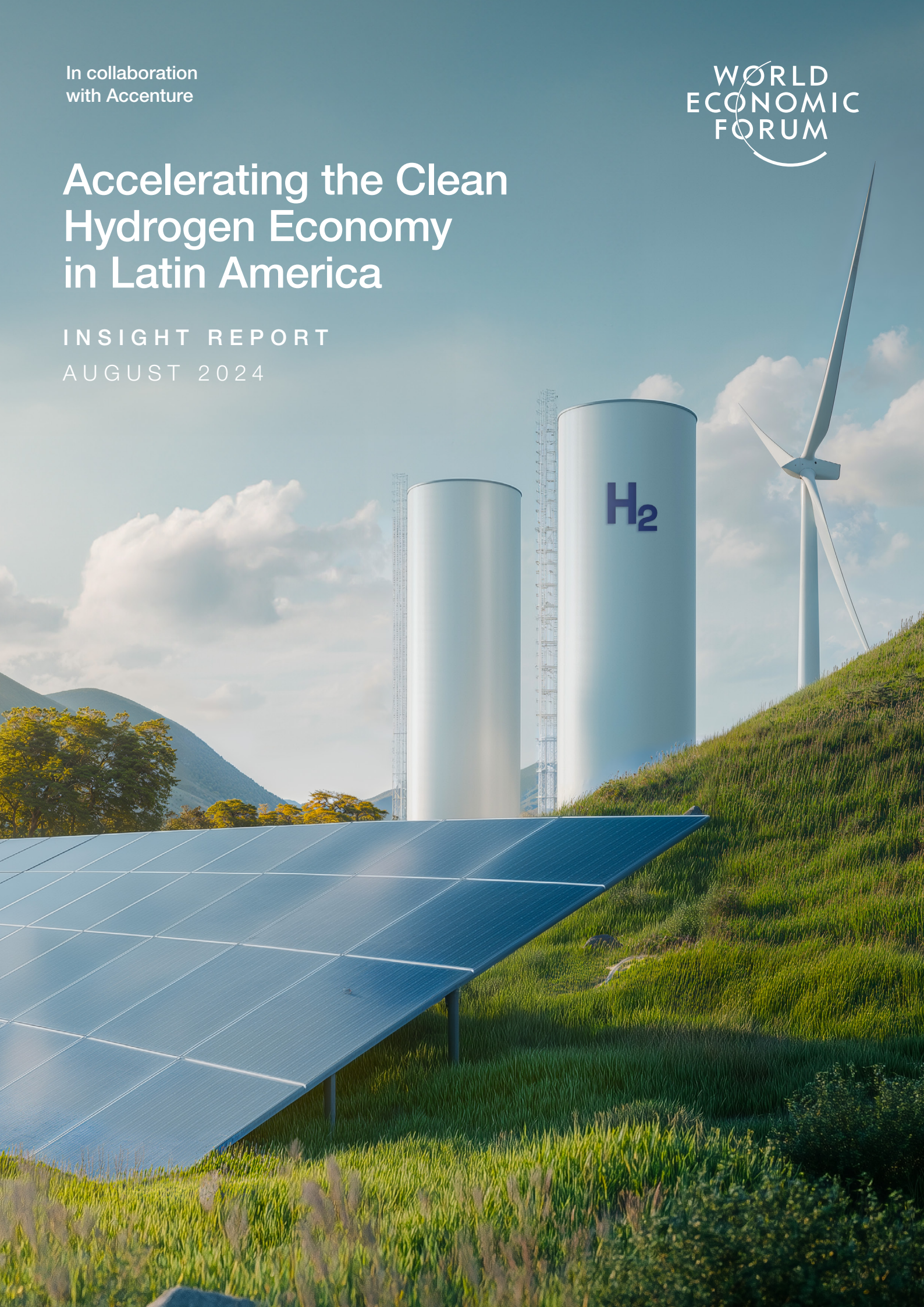
In collaboration with Accenture

WORLD ECONOMIC FORUM

Accelerating the Clean Hydrogen Economy in Latin America

INSIGHT REPORT

AUGUST 2024



Images: Getty Images, Midjourney

Contents

Foreword

Roberto Bocca
Head of Centre for Energy and Materials; Member of the Executive Committee, World Economic Forum

Marisol Argueta de Barillas
Head of the Regional Agenda, Latin America; Member of the Executive Committee, World Economic Forum

Andrés Rebolledo
Executive Director; Latin American Energy Organization, OLADE

Muqsit Ashraf
Group Chief Executive, Accenture Strategy

Last year was the warmest year on record, with global average temperatures 1.45° Celsius above the pre-industrial baseline, according to the World Meteorological Organization.[1] With the past decade also the warmest on record, the quest to find sustainable solutions to address climate change and reduce emissions has become paramount. As nations across the globe commit to ambitious decarbonization goals, the pursuit of cleaner energy sources has taken centre stage. In the journey to achieve net-zero emissions objectives, clean hydrogen stands out as a promising avenue.

In the next decades, clean hydrogen could play an important role in meeting global energy demand, while contributing in the region of 10% of emissions reductions by 2050.[2] It will play a critical role in decarbonizing hard-to-abate sectors (e.g. steel and chemicals) where alternatives cannot fully decarbonize. At the same time in the wider energy ecosystem, it can provide a means of long-duration energy storage complementing intermittent renewables.

Latin America, with its vast installed and potential renewable energy capacity, is poised to play a key role in advancing the clean hydrogen economy. The region can leverage its abundant solar, wind and hydroelectric resources to become a key player in the global clean hydrogen export market. Furthermore, investment in clean hydrogen infrastructure could help address energy security concerns and drive economic growth across the region. It is worth noting that uncertainties and complexities persist regarding the future of clean hydrogen markets, such as the development of cost-effective technologies and market competitiveness.

To realize the potential of the clean hydrogen economy in Latin America, coordinated and decisive efforts are required. The urgency of the moment demands that governments, investors and businesses act with responsibility and ambition:

- Governments must move faster to create policy frameworks that provide incentives for investment and facilitate international collaboration, to accelerate the deployment of clean hydrogen technologies.
- Strategic investments from both public and private sectors are vital to reduce the costs of production and prices for end-users, allowing clean hydrogen to compete with grey hydrogen and other alternative fuels.
- Businesses must embrace innovation, invest in research and development and forge strong and reliable partnerships to drive the transition towards a sustainable hydrogen economy.
- While lessons learned from other regions of the world can provide a beneficial framework, regional nuances must be accounted for.
- As the region embarks on this transformative journey, it is essential that all actors approach the challenges ahead with resolve, optimism and a shared commitment to building a more sustainable world for future generations.

We invite you to delve deeper into the pages of this report, which we hope provides valuable insights into the opportunities and pathways to accelerate the clean hydrogen economy in Latin America. We thank all community members, stakeholders and corporate leaders for their time and contributions to this report; and we look forward to continuing our collaboration as we navigate clean hydrogen challenges and solutions to deliver on a cleaner future.

Executive summary

In the global decarbonization landscape, clean hydrogen has become a crucial element for the energy transition. Given its potential to reduce global greenhouse gas (GHG) emissions in hard-to-abate sectors, such as heavy industry and long-distance transport, clean hydrogen has been gaining traction worldwide. Economies can foster its development through incentives and pilot projects that showcase the benefits of clean hydrogen, promote its production and encourage its demand.

Latin America, with its vast potential in renewable resources (solar, wind and hydro power) can unlock clean hydrogen production at competitive cost, positioning it to become a major clean hydrogen-exporting region and hence a central player in the global clean hydrogen economy. Depending on their intrinsic characteristics, countries within the region have different short- and medium-term clean hydrogen economy development strategies and ambitions. As such, they may follow one of three potential pathways: net exporters, local decarbonizers, or focused players:

- **Net exporters** are countries whose focus is beyond domestic demand, aiming to trade most of their produced clean hydrogen in international markets. They seek to become globally competitive players through cost-effectiveness and the development of necessary trade infrastructure and certification schemes.

- **Local decarbonizers** are countries that are focused first on utilizing clean hydrogen to decarbonize their own economies and meet emission reduction targets, leaving exports to a later stage.

- **Focused players** adopt a more targeted approach to the development of clean hydrogen, focusing on its role complementing existing fuels or energy technologies in a particular application, such as shipping. These countries will prioritize actions that strengthen their position in relation to particular sectors or end-use applications.

The World Economic Forum, in collaboration with Accenture, supports the ambitions of Latin America to become a central clean hydrogen player through the Transitioning Industrial Clusters Initiative, which works with stakeholders across industry, policy and finance to accelerate the clean hydrogen economy in the region. The aim of this report is to identify the challenges and key enablers to the development of the clean hydrogen economy in Latin America, as well as to establish the current maturity level of countries in the region regarding clean hydrogen.

Challenges facing the development of the clean hydrogen economy in Latin America

While there is great potential to accelerate the clean hydrogen economy and become a net exporter in the long term, the region's main challenges are as follows:

1. **Low demand**: Demand for clean hydrogen remains low for both local consumption and exports. Only a small number of offtake agreements are in place and few projects are reaching final investment decisions (FIDs).

2. **Slow pace of building dedicated infrastructure**: Countries have announced several clean hydrogen hubs across the region, but few are under construction or aligned to market creation opportunities.

3. **Technology adaptation and workforce development**: The region is still highly dependent on international manufacturers for key components (e.g. electrolysers). Technology adaptation to local requirements is needed and the sector must develop local highly skilled talent to support further growth.

4. **High cost preventing competitiveness**: Despite competitive prices for renewable energy, there remains a large cost differential between clean hydrogen and conventional/grey hydrogen. Industries and markets are still unwilling to pay the price premium.

5. **Lack of standards and certification**: While regional certification schemes for carbon attributes have advanced rapidly, the region needs a common definition of standards and guidelines to ensure the safe and reliable production, storage and transportation of clean hydrogen and its derivatives. As these regional schemes advance, they will need to integrate with global standards and certifications.

Enabling measures and key success factors to develop the clean hydrogen economy

To address the challenges outlined above, this report defines a series of objectives and enabling measures across six dimensions: 1) standards and certifications, 2) cost, 3) technology and talent, 4) demand, 5) infrastructure and 6) pace of development. These enabling measures, while aimed primarily at governments and policy-makers, also require the participation of other actors in the value chain, including infrastructure, technology, finance and offtakers.

The first three sets of enabling measures below are cross-cutting, while the second three differ by pathway for net exporters, local decarbonizers and focused players.

Standards and certifications

Regional agreements and partnerships are needed to agree definitions for the technical, safety and carbon intensity standards and certifications of the clean hydrogen production value chain, including its derivatives. This approach is needed both to standardize regulations and accelerate their implementation in countries across the region. A “sandbox” approach can be utilized to rapidly test and deploy required regulations.

Cost

To reduce the high costs that prevent clean hydrogen from being price-competitive, targeted government support is needed through well-balanced incentives for clean hydrogen projects across the value chain. Collaboration between nearby industries around sharing resources, for example through industrial clusters, could lead to cost reductions through aggregation of demand and opportunities for scale, while supporting financing.

Technology and talent

One of the main objectives across the region is to focus innovation and research and development (R&D) on scaling-up the technology needed across the clean hydrogen value chain (e.g. electrolysers, carbon capture and storage). For this to happen, greater funding is needed to establish research centres to ensure local technology development. Training programmes to upskill and reskill technical talent are required to support these technology advancements.

Demand

Enabling measures to drive demand vary between the three defined pathways, as follows:

- **Net exporters** must seek to develop early international demand, through signing long-term trade agreements with offtakers and defining operating rules for international trade.
- **Local decarbonizers** need to drive strong local demand for clean hydrogen. Industrial clusters can play a key role in aggregating demand and reducing offtaking risk.
- **Focused players** need to drive demand from the target sector they have defined to serve, for example by signing memorandums of understanding (MOUs), commercializing the technology and testing their value proposition.

Infrastructure

Although all countries in the region must expand or adjust their infrastructure to develop their clean hydrogen economies, there are different enabling measures for each pathway:

- **Net exporters** should focus their efforts on ports and transportation capabilities.
- **Local decarbonizers** should focus on creating centralized infrastructure, such as clean hydrogen hubs in strategic locations to streamline the production, distribution and internal consumption processes.
- **Focused players** should adapt and repurpose their current infrastructure for specific uses, such as localized refuelling stations to boost consumption.

Pace of development

To accelerate the development of clean hydrogen economies, different enabling measures apply to each pathway:

- **Net exporters** must boost resource efficiency by coordinating the development of key infrastructure along the value chain with offtakers, promote knowledge sharing and propose innovative financing mechanisms.
- **Local decarbonizers** must coordinate the ecosystem of actors across the value chain, anchored by industrial clusters.
- **Focused players** need to design and test their value proposition to potential offtakers, involving them in the co-creation process.

Regional collaboration and coordination – the key success factor

Collaboration and coordination at both international and regional levels are key success factors in executing these enabling measures, exploiting synergies and advancing the clean hydrogen economy. Regional collaboration is especially important for Latin America – opportunities include:

1 Identifying regional synergies and opportunities to work together

In an industry that requires enormous scale and investment, working collaboratively can help distribute required efforts and risk, as well as create market consolidation and stability by aggregating regional supply and demand (e.g. through industrial clusters). Similarly it can help accelerate technology and infrastructure R&D by identifying mutual interests.

2 Developing and aligning on regulatory frameworks and certification schemes

Global and regional collaboration can accelerate and improve the effectiveness of appropriate regulatory frameworks and associated certification schemes. Learning from existing regulations and certifications, while adapting them to the Latin American context in a way that respects international standards, can create efficiency and synergy across the region and the world. To achieve this, both regional and international collaboration are equally imperative.

3 Fostering global cooperation and sharing insights

Regular communication with other nations can help countries gain an in-depth understanding of the challenges and bottlenecks facing the development of clean hydrogen. Fostering dialogue is crucial to share best practices and lessons learned, to build a platform from which to advocate for regional requirements, and to obtain support through multilateral organizations or partnerships with other nations.[3]

4 Pursuing an inclusive clean hydrogen economy approach

At a national and regional level, it is important to involve all relevant stakeholders that may be impacted by the development of the clean hydrogen economy. To ensure an inclusive and sustainable transition, it is crucial to convene stakeholders including ministries, industry and businesses, financial institutions, academic and research organizations, local communities and non-governmental organizations (NGOs) to share their perspectives, concerns and needs.[4]

5 Supporting citizens as the clean hydrogen economy emerges

Public acceptance for new technology adoption is crucial to maintain and secure the social licence to operate. Public awareness campaigns can help advocate for the role of clean hydrogen in the energy transition and its benefits for local communities. Additionally, collaboration with neighbouring countries to improve the region's visibility and promote it as an important clean hydrogen production hub could help attract greater international investment and support.

Overview of regional progress

While the challenges and enabling measures relate to the region, the clean hydrogen landscape in each country differs widely. Given the potential for renewable energy in the region, most countries anticipate that renewable/green hydrogen will see greater development compared to blue hydrogen (see Box 1 for definitions).

This report provides a detailed analysis of the clean hydrogen landscape in Argentina, Brazil, Chile, Colombia, Mexico, Panama and Uruguay. The main highlights by country are as follows:

Argentina expects that by 2030 more than 80% of its renewable/green hydrogen demand will come from international markets. The country's *National Strategy for the Development of the Hydrogen Economy,* published in 2023, seeks to take advantage of its abundant renewable resources (including the largest potential for photovoltaic energy production globally) and strategically positioned ports that will be adapted for clean hydrogen exports. Argentina expects to renovate nine of its 16 ports by 2030 and aims to develop at least five clean hydrogen hubs.

Brazil published its *National Hydrogen Program (PNH2)* in 2022. The purpose of PNH2 is to boost the clean hydrogen market and industry as an energy vector in Brazil, highlighting its relevance in the country's energy transition and in achieving net zero by 2050. To accelerate progress, Brazil is investing in infrastructure for a renewable/green hydrogen hub at Pecém Port, while a Brazil-Netherlands maritime corridor is being established to facilitate renewable/green hydrogen exports to Europe.

Chile published its *National Green Hydrogen Strategy* in 2020, the first such strategy in the region, with the objective of becoming a frontrunner in renewable/green hydrogen production and export.

Chile has the potential to produce the world's cheapest renewable/green hydrogen by 2050,[5] by exploiting its potential for more than 1,800 GW of installed renewable energy capacity by 2050 – 70 times the demand from domestic internal consumption.[6] The government has drawn up a regulatory framework and fast-tracked three pilot initiatives for renewable/green hydrogen technology in production, mining and transport.

Colombia made an early start with its *Hydrogen Roadmap* in 2021. The government is committed to decarbonization and the creation of public policies that promote the adoption of clean hydrogen at the local level. The country expects to improve its production capacity and infrastructure with 28 projects in the pipeline and six potential hubs operational in different regions by 2050.

Mexico has not yet created a national strategy to develop the clean hydrogen economy. To date, the Mexican Hydrogen Association has led the way, publishing a renewable/green hydrogen roadmap up to 2050 to promote investment in developing renewable/green hydrogen to decarbonize the national economy. Most of the demand is forecast to come from the industrial and transportation sectors. Mexico has nine projects in development, all harnessing dedicated renewable energy sources for renewable/green hydrogen and ammonia production.

Panama published its *National Strategy for Green Hydrogen and Derivatives* (ENHIVE is its Spanish acronym) in 2023. The country's main goal is to develop its port infrastructure and become a major hub for green refuelling for the maritime sector, where clean hydrogen plays a key role. Panama has one project underway at the feasibility study stage (SGP BioEnergy's bio-refinery), which aims to be operational by 2025 with a target of producing 405,000 tonnes of renewable/green hydrogen per year.

Uruguay released its *Green Hydrogen Roadmap* in 2022, to help boost domestic demand for fuels such as ammonia and low-emission e-methanol for maritime transport. Uruguay is committed to integrating renewable/green hydrogen into its energy mix, by taking advantage of its logistics infrastructure and its experience in terms of regulation, legal requirements and political stability gained while developing renewables. The country is progressing with four projects focused on renewable energy sources for hydrogen and synthetic fuel production.

Introduction

The development of the clean hydrogen economy is crucial for the fulfilment of decarbonization goals and the success of the energy transition around the world. Clean hydrogen holds great potential as a means to decarbonize hard-to-abate sectors, being both a clean energy carrier and a clean feedstock substitute for diverse industrial processes.

In recognition of this opportunity, Latin American countries have started the journey towards developing their clean hydrogen economies. Leveraging their excess renewable energy capacity, most countries in the region have set out their ambitions and are beginning to execute. While following different pathways, the region as a whole aims at becoming a net clean hydrogen exporter by 2050.

This report provides a comprehensive summary of the current state of the clean hydrogen economy in Latin America. Informed by consultations with key industry stakeholders and governmental organizations, this report describes the challenges and enabling measures that, if realized, could accelerate the production and use of clean hydrogen across the region.

This report is structured as follows:

- **Chapter 1**: explores the region's role in the global clean hydrogen economy, its potential and the pathways likely to be followed by each of the seven countries.
- **Chapter 2**: provides insights into the challenges facing the development of the clean hydrogen economy in Latin America.
- **Chapter 3**: describes the enabling measures and key success factors to accelerate the development of the clean hydrogen economy.
- **Conclusion:** provides the report's final insights.
- **Appendix**: provides an in-depth view of seven prioritized countries with the highest potential to develop clean hydrogen in the region.

The methodology followed to build the report consisted of both desk research and engagement with key stakeholders. The desk research included reviewing available reports, policies, laws, national strategies and roadmaps on current hydrogen development. This analysis was complemented by one-on-one interviews and focus groups with regional private and public stakeholders to validate findings on challenges and enabling measures. Finally, collaborative sessions were held to consolidate insights into lessons learned across the region and to identify and promote opportunities for cooperation.

BOX 1 **Clean hydrogen – definition**

"Clean hydrogen" refers to hydrogen produced through the following two methods:

- Produced from water by electrolysis, powered from renewable sources – known as "renewable" or "green" hydrogen.
- Produced from natural gas by a process of steam methane reforming (SMR), in conjunction with carbon capture and storage (CCS) – abbreviated to SMR+CCS and known as "blue" hydrogen.

Both have significantly reduced emissions compared to conventional "grey" hydrogen. Green hydrogen is the most sustainable and preferred pathway, while blue hydrogen can contribute towards a rapid shift away from unabated fossil fuels.

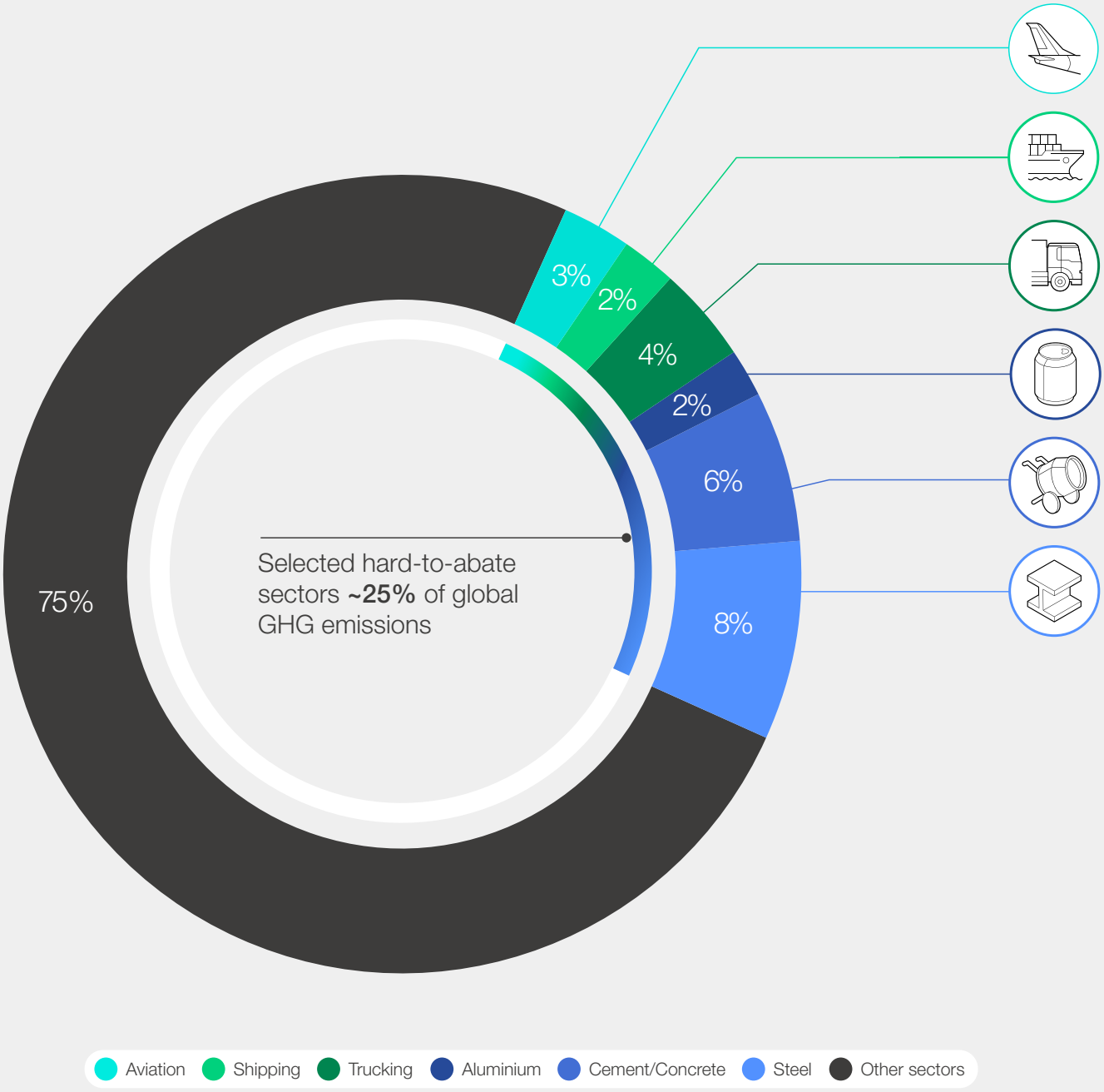
1 Latin America in a global context

Clean hydrogen can play a key role within the global energy transition.

1.1 Clean hydrogen – the global context

Given its potential to reduce the use of fossil fuels, clean hydrogen has been gaining traction as a crucial element to reduce global greenhouse gas (GHG) emissions in hard-to-abate sectors, such as aviation, shipping, trucking, aluminium, cement/concrete and steel, which account for around 25% of global GHG emissions (see Figure 1). While in industry, clean hydrogen can function both as a feedstock substitute in processes and as a heat source, it also plays a role as an energy carrier in heavy-duty transportation.

FIGURE 1 **Share of selected hard-to-abate sectors in global greenhouse gas emissions**

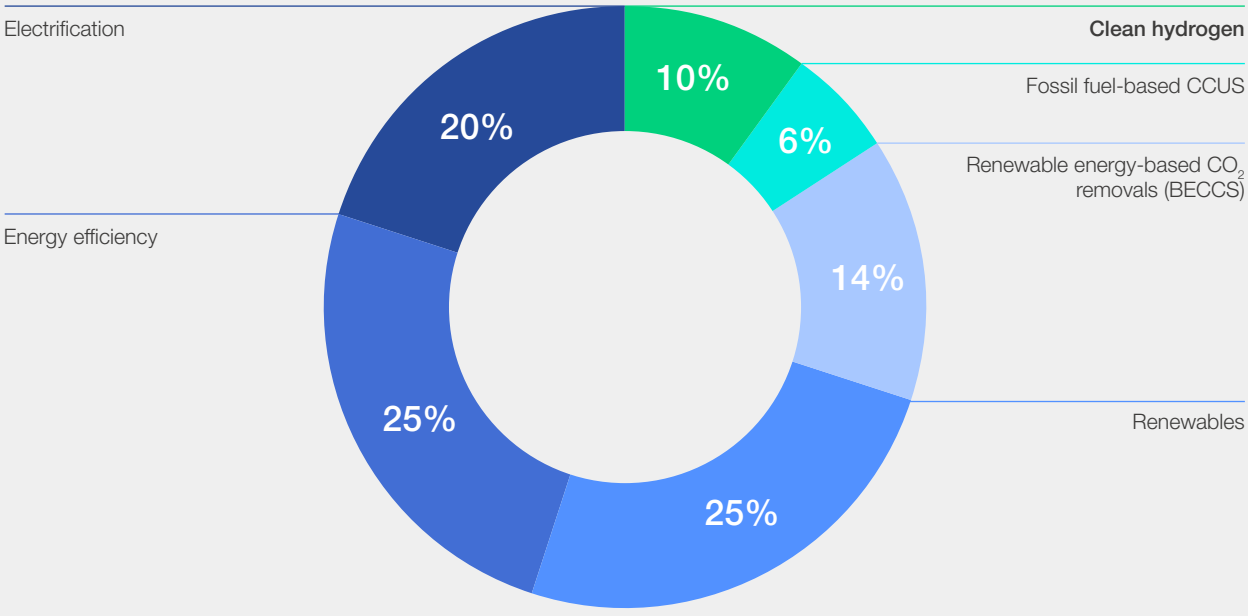


Source: World Economic Forum.[7]

Moreover, at a global level, clean hydrogen is among the six leading technological avenues for reducing emissions. The technology could potentially contribute to around 10% of the emissions reductions required to reach net zero by 2050 (see Figure 2).

> Clean hydrogen could contribute to **around 10%** of the emissions reductions required to reach net zero by 2050.

FIGURE 2 **Global net-zero emissions reduction contributions of six technological avenues, by 2050**



Notes: CCUS = Carbon capture, utilization & storage; BECCS = Bioenergy with carbon capture & storage.

Source: Inter-American Development Bank, 2023.[8]

1.2 Renewable energy can unlock Latin America's clean hydrogen future

As a region endowed with vast renewable energy resources, Latin America is poised to become a significant clean hydrogen player in the coming years. In the period 2017-2022, renewable electricity capacity in Latin America grew by 81.7 GW, while it is forecast to grow by 154.5 GW in the period 2023-2028 (see Figure 3). Solar and wind power are projected to be the main drivers of this growth.

The continent's abundant renewable energy capacity enables Latin America to be competitive in one of the key cost drivers of clean hydrogen production. This is a significant advantage, as renewable electricity accounts for 60% to 75% of the total production cost of clean hydrogen globally.[10]

The advantage becomes evident in the differences between the regional and global "levelized cost of hydrogen" (LCOH) for renewable/green hydrogen. In Latin America, the current LCOH of renewable/green hydrogen is $3.70–$5.90/kg (2020 prices),[11] lower than the current global LCOH of $3.80–$8.50/kg (2021 prices).[12]

> Renewable electricity accounts for **60%–75%** of the total production cost of clean hydrogen globally.

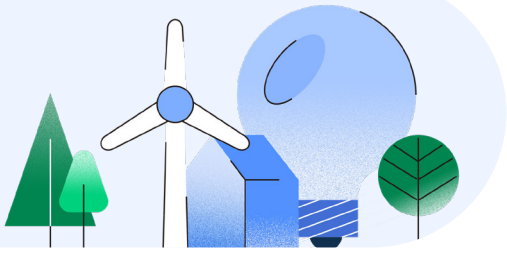
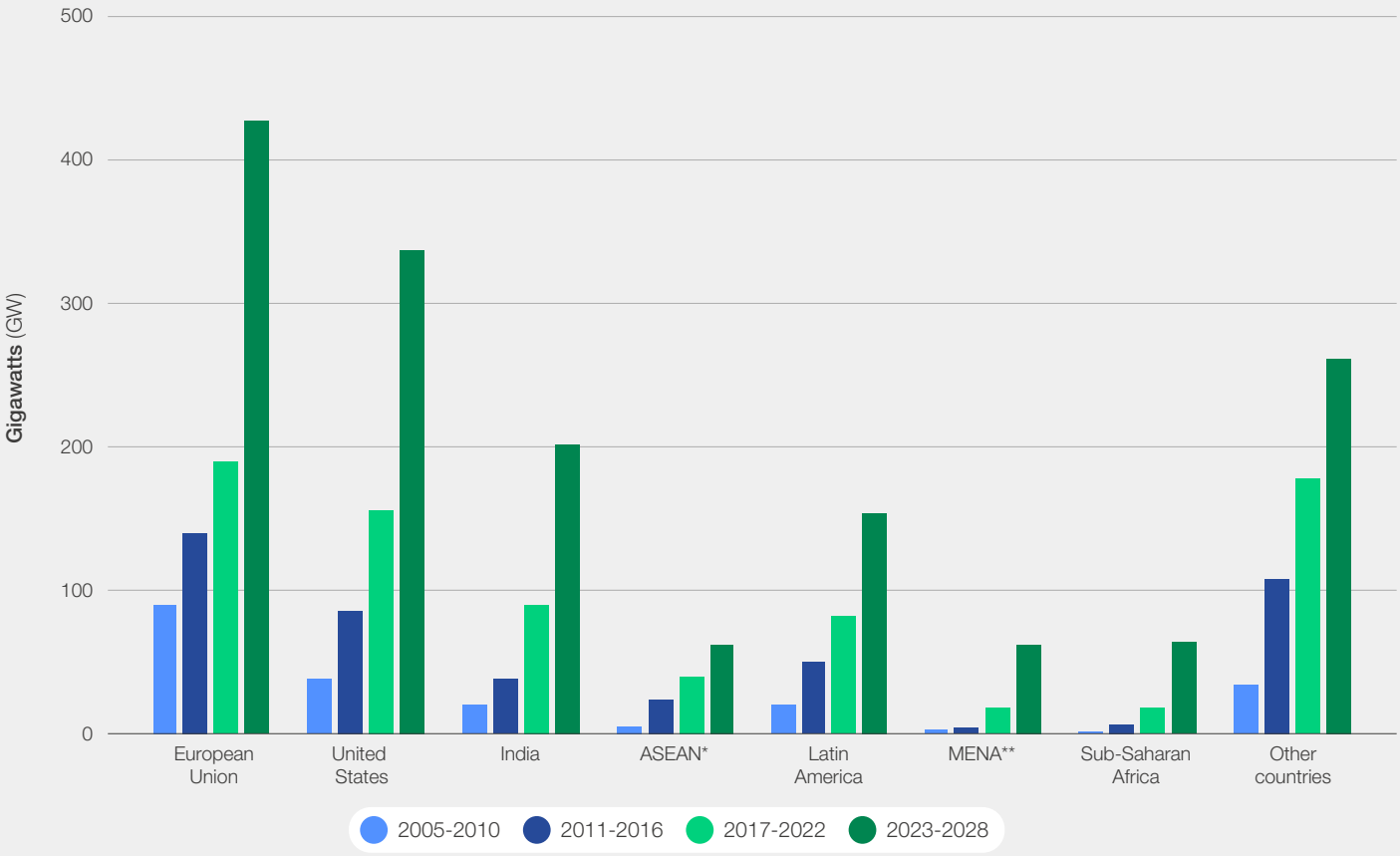
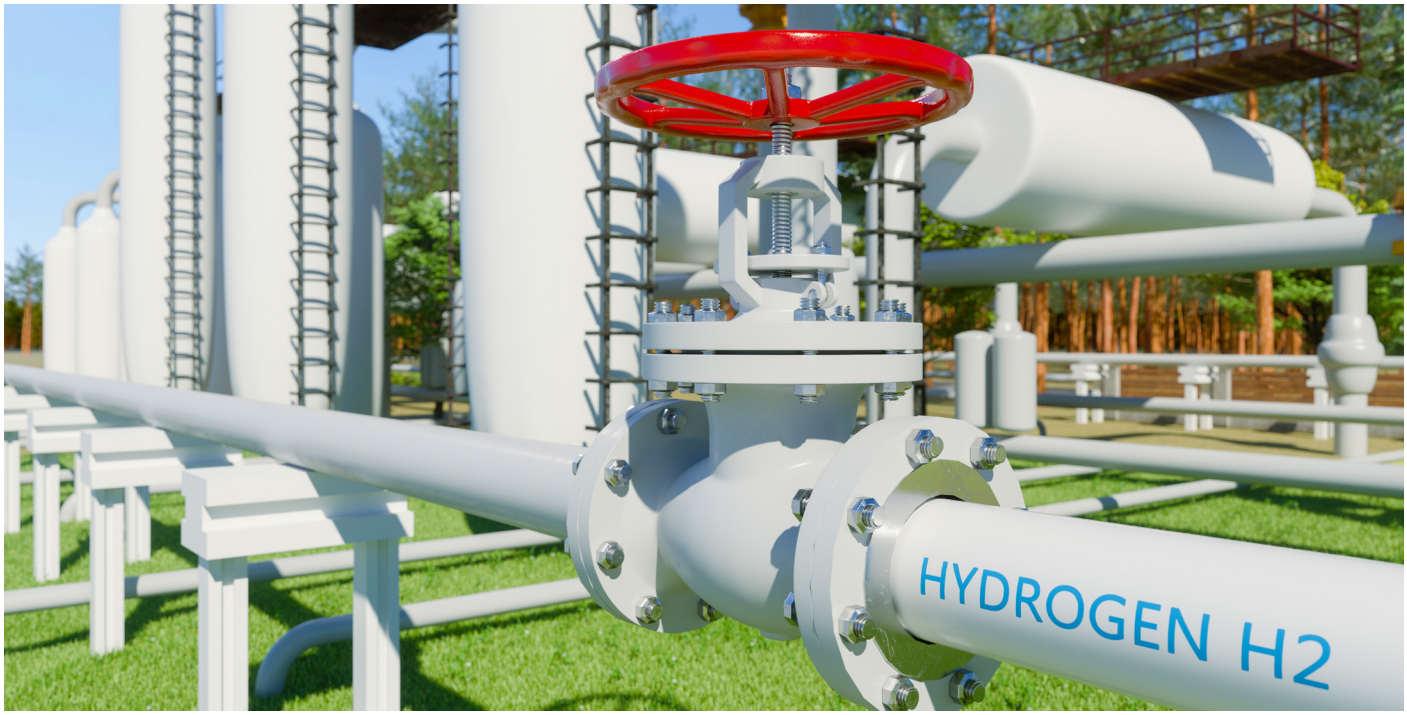


FIGURE 3 **Global renewable electricity capacity growth by region, 2005-2028**



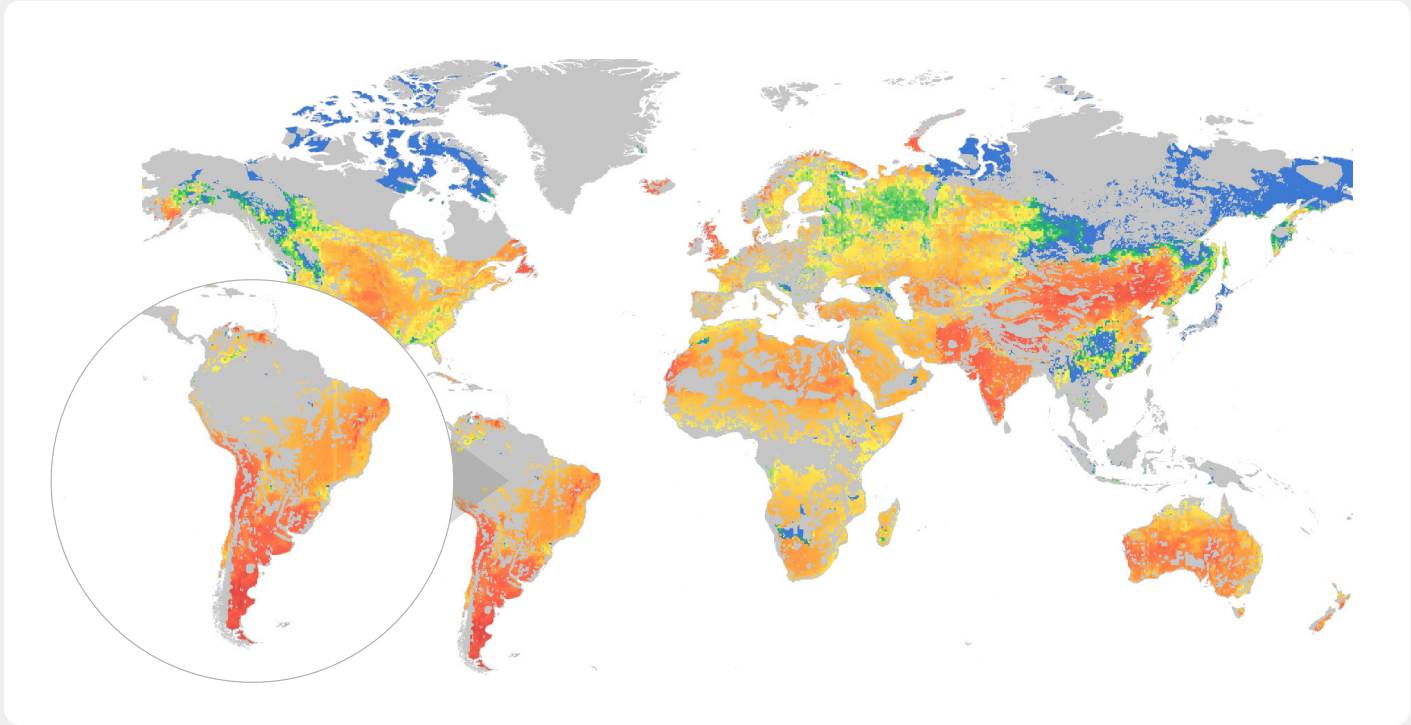
Notes: *ASEAN = Association of Southeast Asian Nations; **MENA = Middle East and North Africa.

Source: IEA, 2024.[9]



As shown in Figure 4, the region's levelized cost of renewable/green hydrogen by 2030 is forecast to be particularly low for production in the south of Argentina and Chile, north-western Brazil and northern Colombia and Venezuela.

FIGURE 4 **Global levelized cost of renewable/green hydrogen, by 2030**



Levelized cost of renewable/green hydrogen ($/kg H_2)

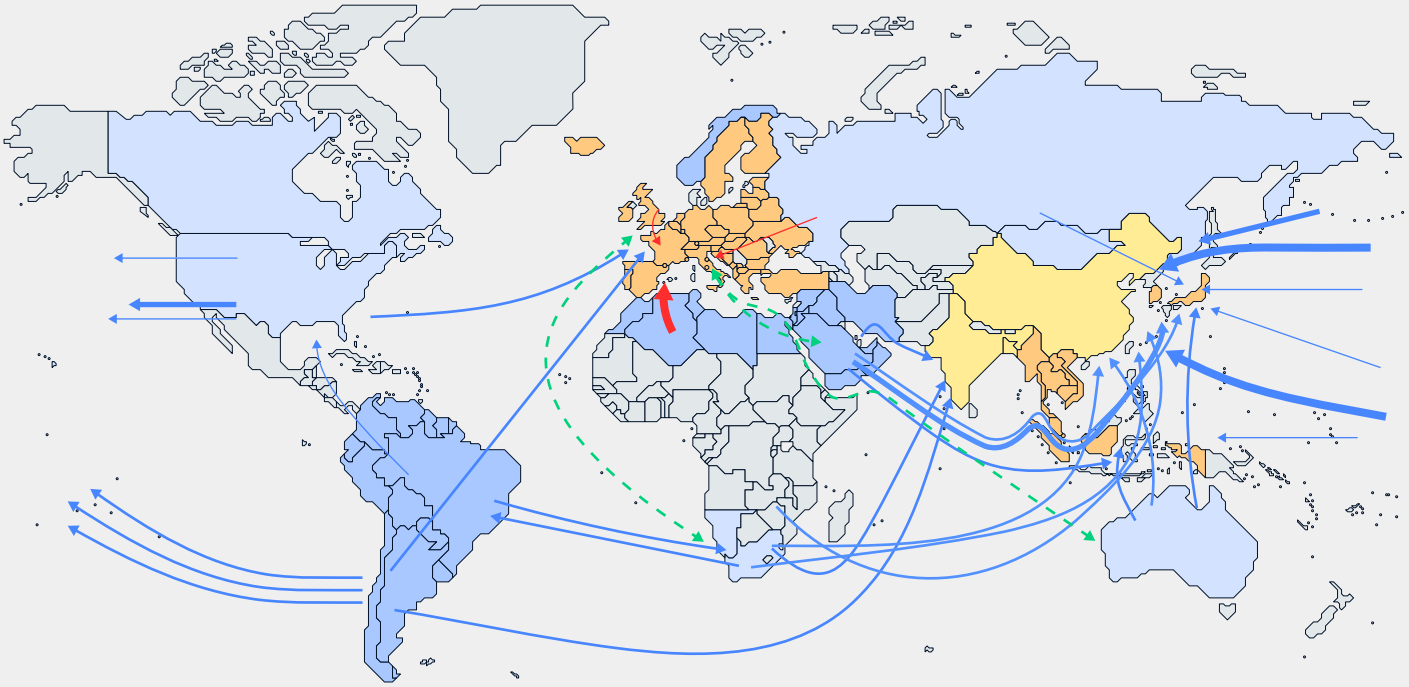
1.5 2.0 2.5 3.0 3.5 4.0

Source: IEA, 2021.[13]

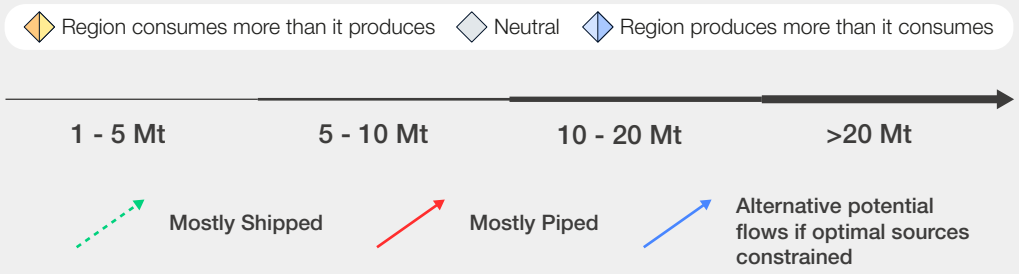
These favourable conditions – of high renewable energy capacity and low cost of clean hydrogen production – can position the region as a potential net exporter to global markets, both in the medium- and long-term. By 2030, the region may fulfil 25% to 33% of global demand, competing with Australia (22%–31%) and Africa (9%–14%).[14] By 2050, Latin America is predicted to be exporting clean hydrogen mainly to Europe and Asia, as reflected in Figure 5.

To fulfil its potential and to capitalize on this opportunity, Latin America has been working on developing the required infrastructure. To date, 11 potential clean hydrogen hubs[16] have been identified across the region, in countries including Chile, Brazil and Panama (see Figure 6). At the same time, other potential exporting regions are working towards the same goal – for example, the United States (US) has announced 10 hubs, while Australia has announced seven.[17]

FIGURE 5 **Expected global clean hydrogen trade flows and regional roles, by 2050**



Net trade flows, million tonnes (Mt) of hydrogen per annum



Source: Hydrogen Council, 2022.[15]

FIGURE 6 | **Potential clean hydrogen hubs in Latin America**

Source: Inter-American Development Bank, 2023.[18]

In summary, when compared with other regions, the clean hydrogen economy landscape in Latin America looks promising. The region is well-endowed with cost-competitive renewable energy resources that position it as net exporter by 2050. Nonetheless, other potential competitor regions are progressing as well, so it is important for Latin America to accelerate in this sector to build competitive advantage in the coming years.

The following section explores the different pathways that countries in the region could follow and the challenges they will need to overcome to maximize the opportunities offered by the clean hydrogen economy.

1.3 Three potential pathways for Latin American countries

While the region is likely to become a net exporter of clean hydrogen in the long run, countries within the region have different clean hydrogen development strategies and ambitions, which could see them follow one of three potential pathways:

- Net exporters
- Local decarbonizers
- Focused players

This report allocates selected countries in the region to one of the three pathways, based on an analysis of their national hydrogen roadmaps and other relevant announcements (see Figure 7). These pathways are not intended to define a fixed route for each country nor to oversimplify the multiple efforts of countries now and in the future to transform their energy economies. The value of defining and allocating pathways is that it allows countries to prioritize key actions, based on their differing short-, medium- and long-term goals. The main characteristics of each pathway are detailed below.

FIGURE 7 **Potential clean hydrogen economy pathways for Latin American countries**

> Two countries in the region have demonstrated ambition to become net exporters: Chile and Argentina.

Net exporters

Countries that follow the net exporters pathway have strategies aimed at trading the majority of their clean hydrogen production to international markets.

Roadmaps for countries within this category seek to position themselves as relevant global competitive players. To achieve this, they have focused initial efforts beyond production and are incentivizing the construction of dedicated clean hydrogen export infrastructure – including ports and clean hydrogen hubs – that will help reduce transportation costs and improve price competitiveness.

Moreover, they have adopted certification schemes aligned to international standards, rather than creating national ones. They have built research centres and developed alliances (national, regional and international) to advance commercial agreements specifically focused on clean hydrogen trading.

These net exporters have planned for a clean hydrogen economy that takes advantage of their country's current capabilities and maximizes them for competitiveness in markets where demand is growing. Nevertheless, it is important to note that while these countries are focusing on exports, they are also targeting domestic sectors that will in turn contribute to national decarbonization goals and support the development of the domestic clean hydrogen economy.

Two countries in the region have demonstrated ambition to become net exporters: Chile and Argentina.

Chile

Chile, which has the potential to produce the world's cheapest renewable/green hydrogen by 2050, offers an example of the projected pathway of a net exporter. With the potential for more than 1,800 GW of installed renewable energy capacity by 2050 (70 times the country's demand for internal consumption),[19] Chile has the ambition to become a frontrunner in the race. In 2020, it was the first country in the region to publish a *National Green Hydrogen Strategy* and it has already reviewed that strategy to focus on execution at scale.

Chile has captured $550 million of multilateral investment in clean hydrogen projects, $150 million from the World Bank[20] and $400 million from the Inter-American Development Bank.[21] In collaboration with the German government, Siemens Energy is developing the world´s first integrated commercial installation to produce climate-neutral fuel near the Patagonian city of Punta Arenas. In addition, the government is progressing the ratification of a trade agreement with the European Union (EU) that will allow clean hydrogen to be traded freely.

Argentina

Displaying similar ambition, Argentina expects that by 2030 more than 80% of its demand for clean hydrogen will come from international markets. To implement its *National Strategy for the Development of the Hydrogen Economy,* published in 2023, the country is leveraging its abundant renewable resources (including the world's largest photovoltaic energy potential) and its 16 strategically positioned ports, which can be adapted for clean hydrogen exports. Argentina expects to renovate nine of these ports by 2030 and aims to develop at least five clean hydrogen hubs.

The Argentinian government is making progress in creating policies and standards. Lately, the "Promotion of Low Carbon Hydrogen and Other Greenhouse Gas Emissions" bill was passed with the purpose of promoting clean hydrogen production projects, organizing governance of the sector and encouraging productive and technological development along the entire value chain.

> Three countries in the region have demonstrated ambition to become local decarbonizers: Brazil, Colombia and Mexico.

Local decarbonizers

The short- and medium-term goals for countries aligned to this pathway are mostly focused on decarbonizing the national economy and meeting emissions reduction targets, prioritizing a local clean hydrogen market and leaving exports to a later stage. To achieve this, local decarbonizers seek to replace conventional/grey hydrogen and enable new uses in hard-to-abate sectors through piloting solutions with clean hydrogen. These countries have not yet set clear demand projections for international markets and their confirmed projects seek to increase production capacity to meet future local demand and drive domestic consumption by reducing cost through government incentives.

Countries that follow this pathway have – or are developing – national certifications for clean hydrogen with standards that can be different for domestic and international markets. This allows them to customize standards to meet local requirements, while also ensuring compliance with international standards and facilitating future commercialization to other markets.

Three countries in the region have demonstrated ambition to become local decarbonizers: Brazil, Colombia and Mexico.

Brazil

Brazil, whose *National Hydrogen Program (PNH2)* does not establish specific goals for clean hydrogen production and use, has nevertheless established clean hydrogen as central to the country's energy transition to achieve net zero by 2050. Through PNH2, the government has framed public policies and financial mechanisms – including tax relief, green finance and dedicated funds for renewables – to increase the competitiveness of the clean hydrogen sector.

Through this approach, the government seeks to position Brazil as the country with the lowest production costs for clean hydrogen in the world by 2030, by which time approximately 60% of the country's total clean hydrogen supply is expected to be consumed domestically.

Although the country's main near-term policies are aimed at boosting domestic demand, the Ministry of Mines and Energy expects the country to be a major global hydrogen exporter by 2050. To further this vision, a joint venture between the Port of Pecém, in the State of Ceará, and the Port of Rotterdam is investing in building infrastructure for a renewable/green hydrogen hub at Pecém and a Brazil-Netherlands maritime corridor to facilitate the export of renewable/green hydrogen to Europe.

Colombia

Colombia, situated between two oceans, with a water supply six times the world average,[22] 10 port areas, plus wind and solar potential along its coastlines, has the potential to become an important global clean hydrogen logistics hub. However, the country's near-term ambition is to decarbonize its economy through steering clean hydrogen production towards industrial and transportation applications. By 2050, the government expects 40% of the hydrogen consumed by the industrial sector to be clean hydrogen.[23]

Colombia's commitment to decarbonization is reflected in its public policies, which seek to boost domestic clean hydrogen consumption and reduce production costs by offering fiscal benefits associated with emissions reductions. One example is Law 2099 of 2021, which prioritizes investments from the non-conventional energy and efficient energy management fund (FENOGE) according to their impact on reducing emissions.

Mexico

Mexico has favourable conditions to produce clean hydrogen, given its robust power and gas transmission networks, and hydro power, solar PV and wind plants. However, the country has not yet established a national strategy to develop a clean hydrogen economy.

Even though there is no national hydrogen strategy, efforts have been led by the Mexican Hydrogen Association, which forecast that by 2030 most of the demand for clean hydrogen will come from the industrial sector (e.g. glass, cement, chemicals), while by 2050 most demand will come from the transportation sector. The country is progressing with nine projects that all harness dedicated renewable energy sources to produce renewable/green hydrogen and ammonia.

> Focused players are countries that have limited the scope of hydrogen to a specific role where it complements an existing offering. Two countries in the region have demonstrated focused ambition: Panama and Uruguay

Focused players

Focused players are those that have a much more targeted approach to the development of clean hydrogen. Countries following this pathway have limited the scope of hydrogen to a specific role where it complements an existing offering; consequently they will prioritize actions that further strengthen their position in that domain.

Panama

Panama is a leading example of a focused player. In light of its strategic location as a logistics hub astride the Atlantic and Pacific Oceans, the country – as part of its *National Strategy for Green Hydrogen and Derivatives (ENHIVE)* launched in January 2024 – has designed a masterplan to create an industrial hub to produce, import, export and trade clean energy sources for the maritime sector. The plan focuses on bunkering products made with clean hydrogen, such as green ammonia and e-methanol.

To date, the country has one project underway at the feasibility study stage (SGP BioEnergy's bio-refinery), which aims to be operational by 2025 with a target of producing 405,000 tonnes of renewable/green hydrogen per year.

Panama is also preparing a detailed study on the potential demand for green ammonia, e-methanol and renewable/green hydrogen to fuel ocean-going vessels transiting the Panama Canal, with growth projections for 2030, 2040 and 2050.

Uruguay

Uruguay's strategy for developing a clean hydrogen economy is focused on supplying local demand for fuels, such as hydrogen for trucking and low-emission ammonia and e-methanol for maritime transport. In its most optimistic local demand scenario, Uruguay predicts that hydrogen fuel-cells will power approximately 3% of heavy-duty vehicles by 2030, increasing to 35% by 2050.

The country is moving forward with four projects, each at various stages of development and focusing on renewable energy sources for clean hydrogen and synthetic fuel production. For example, the H24U project, previously known as Proyecto Verne, is at the feasibility study stage, aiming to be operational by 2025 with a target of installing 5 MW of clean hydrogen production capacity. Meanwhile, the Paysandu green hydrogen project, also at the feasibility study stage, has set its sights much higher: by 2026, it is planning to produce 256 million litres of eGasoline per year (using 100,000 tonnes of renewable/green hydrogen).[24]

2 Challenges to overcome in Latin America

Demand is still lagging for both domestic and export markets, while dedicated clean hydrogen infrastructure and technology advancements are required to accelerate the pace.

Despite the region's potential to become an important player and net exporter in the global clean hydrogen economy, Latin America faces a variety of barriers. From low demand and scarce local infrastructure to technology challenges and high costs, the journey to develop the clean hydrogen economy remains highly uncertain.

This chapter applies the *Accelerating Clean Hydrogen Framework* (developed by the World Economic Forum in collaboration with Accenture) to review the challenges hampering the progress of the clean hydrogen sector in the region. In applying this framework to Latin America, differences and commonalities at a country level can be identified.

2.1 Accelerating Clean Hydrogen Framework

The *Accelerating Clean Hydrogen Framework* provides six dimensions through which to analyse the current state of Latin America's clean hydrogen economy:

- Standards and certification
- Demand
- Cost
- Infrastructure
- Technology and talent
- Pace of development

For each dimension, high-level objectives define the priority actions required to overcome the barriers within that dimension that impede the acceleration of the clean hydrogen economy in Latin America (see Figure 8).

FIGURE 8 **World Economic Forum's *Accelerating Clean Hydrogen Framework***

Objectives

Standards & certifications
Ensure clarity on carbon intensity, safety and technical standards and certifications for projects across the value chain.

Cost
Remove cost and regulatory barriers for production and support the bankability of projects for investors.

Technology & talent
Focus on innovation and R&D to improve bankability and cost, efficiency and durability of electrolysers, renewables and CCS. Adapt workforce and skills to deploy new technologies.

Demand
Drive critical mass demand through major clean hydrogen projects to ensure high supply. Leverage domestic and international targets to create stable, long-term demand.

Infrastructure
Align clean hydrogen hubs and infrastructure with market creation, ensuring first ramp-up of "no regret" infrastructure: clean electricity, CCS, transport, storage, conversion and trade facilities.

Pace of development
Accelerate slow pace of clean hydrogen scale-up and development to drive economies of scale, coordinating the ecosystem.

2.2 Challenges across six dimensions

drop in renewable energy costs globally in past decade – electricity at $0.02/kWh needed for competitive H_2 production.

The following sections analyse the challenges the Latin America region faces in each of the six dimensions outlined in the *Accelerating Clean Hydrogen Framework.* The first three dimensions – standards and certification, cost, technology and talent – display commonalities across the three clean hydrogen development pathways and therefore do not require differentiated analysis. However, the second three dimensions – demand, infrastructure, pace of development – require a differentiated analysis that addresses the particularities of each pathway.

Cross-cutting challenges

Standards and certification

There have been important efforts in the Latin America region to establish standards that enable the development of the clean hydrogen economy as well as efforts to build clean hydrogen certification schemes. The main challenges relate to:

- **Lack of standards for production and utilization of clean hydrogen**: this generates uncertainty for producers, offtakers and investors in the region. The absence of even minimal regulation creates loopholes and uncertainties around required processes to be followed.
- **Lack of alignment between domestic and international standards**: some countries in the region either have no certification schemes in place or are building domestic schemes that are not aligned to international standards. This not only threatens the legitimacy of the clean hydrogen being produced, but also creates barriers to offtakers in managing differences from one country to another in the region.

Cost

Clean hydrogen production is not yet cost-competitive in comparison to conventional/grey hydrogen and other fossil fuel alternatives; consequently the business case for investing in clean hydrogen is not yet sufficiently convincing.

The two main variables driving the production cost of clean hydrogen are:

- **Cost of electrolysers**: In 2022, the average global cost of electrolysers ranged from $1,400 to $1,770 per kWe.[25] By 2030, this cost is expected to be 3.5 times lower.[26] Despite this encouraging global trend, current prices present a challenge for large-scale clean hydrogen projects in Latin America.
- **Cost of renewable energy generation**: Although the cost of renewable energy, both wind and solar, has decreased by more than 70% globally over the past decade, the levelized cost of electricity (LCOE) must continue to decrease to ensure a competitive cost for clean hydrogen against its conventional/grey alternative. According to the International Renewable Energy Agency (IRENA),[27] electricity costs of $0.02/kWh are needed for competitive hydrogen production. While some Latin American countries like Mexico, Uruguay and Brazil had achieved a LCOE between $0.02/kWh and $0.05/kWh for onshore wind electricity generation by 2022, this is not yet the case across the board.[28]

> Global announced electrolyser manufacturing capacity was ~10 GW/yr in 2021 – by 2030 it is predicted to be 130+ GW/yr.

In addition to these two main cost variables, costs along the entire value chain need to be taken into account, such as for construction, operating, maintenance and transportation. A lack of public policy to incentivize investment and improve project bankability in Latin America has hampered the development of clean hydrogen projects. While governments in other regions provide investors, producers and offtakers with incentives to develop and utilize clean hydrogen, such as fiscal incentives and government financing, Latin America still lags behind in the robust policies needed to encourage development in the sector.

Technology and talent

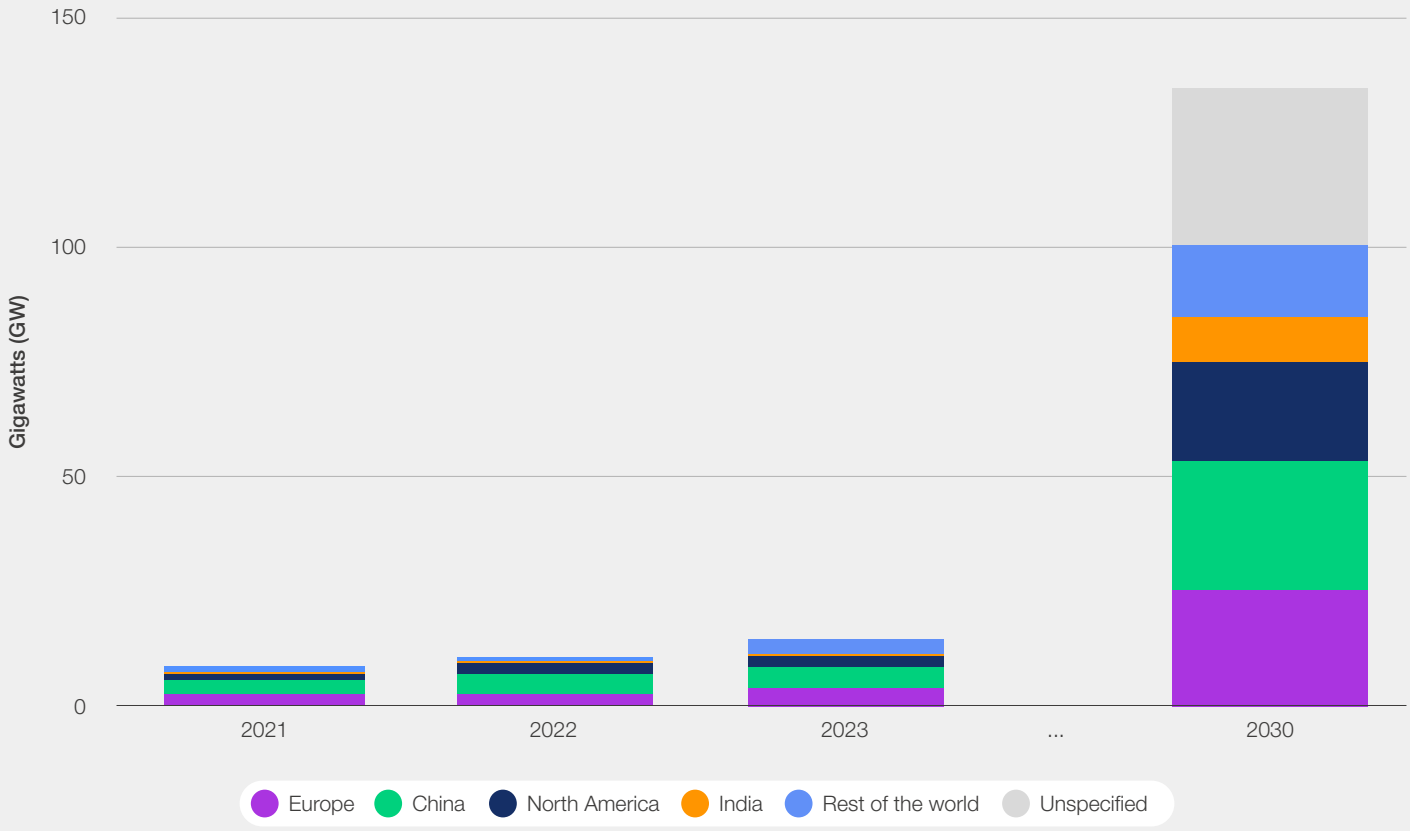
To increase the feasibility of clean hydrogen's usage as a central component in the energy transition, there needs to be further development in the effectiveness and availability of technology, such as electrolysers and carbon capture and storage (CCS), as well as investment in the right skills to operate that technology.

Globally, there is scale-up underway for clean hydrogen technology. While the global announced electrolyser manufacturing capacity was around 10 GW/year in 2021, by 2030 it is predicted to be over 130 GW/year. Europe and China will be the largest manufacturers by the end of the decade (see Figure 9). Improvements in electrolyser efficiency, as well as CCS and infrastructure, are required to unlock the full potential of a clean hydrogen economy.

Latin America is subject to specific operational conditions, such as poor water quality, which could affect the efficiency and effectiveness of technology that has been developed elsewhere. For example, an important distributor of natural gas in Colombia's north-east measured just 35% effectiveness of an imported electrolyser at one of its pilot projects. As this case shows, electrolysers need to be adapted to the region's particular characteristics, where largely saline water sources – requiring desalinization – may affect the effectiveness of existing technologies and increase costs.[29] Domestic research and development (R&D) is needed to adapt emerging technologies to local conditions, both in production and offtake.

Latin America currently faces key challenges in terms of the availability of a skilled workforce equipped with the necessary capabilities across the clean hydrogen value chain. In a survey conducted by the Institute of the Americas in 2022, when asked about the main elements limiting current workforce participation in the energy transition, "lack of the right skills" was mentioned by around 25% of respondents.[30]

FIGURE 9 **Global announced electrolyser manufacturing capacity in GW/year, 2021-2030**



Source: IEA, 2022.[31]

Pathway-specific challenges

Demand

According to IRENA,[32] global demand for hydrogen, mostly clean hydrogen, will not take off until 2035. Moreover, the global trend suggests that by 2050, two-thirds of production is projected to meet domestic demand, while the remaining one-third will be for export. Latin America faces challenges to foster demand development to match potential supply. Depending on their specific pathways, Latin American countries face different concerns.

Net exporters:

- Net exporters need to address international demand and secure international offtakers to ensure their role in global trade dynamics.
- Even with global projected demand, Latin America lacks sufficient signed offtake agreements to secure demand and provide strong certainty to emerging clean hydrogen suppliers.
- As clean hydrogen gains prominence, countries will compete for market share. Net exporters need to ensure they can produce sufficient quantities of clean hydrogen at very low prices to gain and maintain competitiveness in global markets. It is essential to reduce prices, particularly of transport and storage technologies.
- Developing sufficient supply capacity to provide a reliable source of clean hydrogen for importing nations will be an important challenge to overcome.
- Challenges regarding regulation compliance and alignment with international standards will arise if production methods do not align with international regulations.

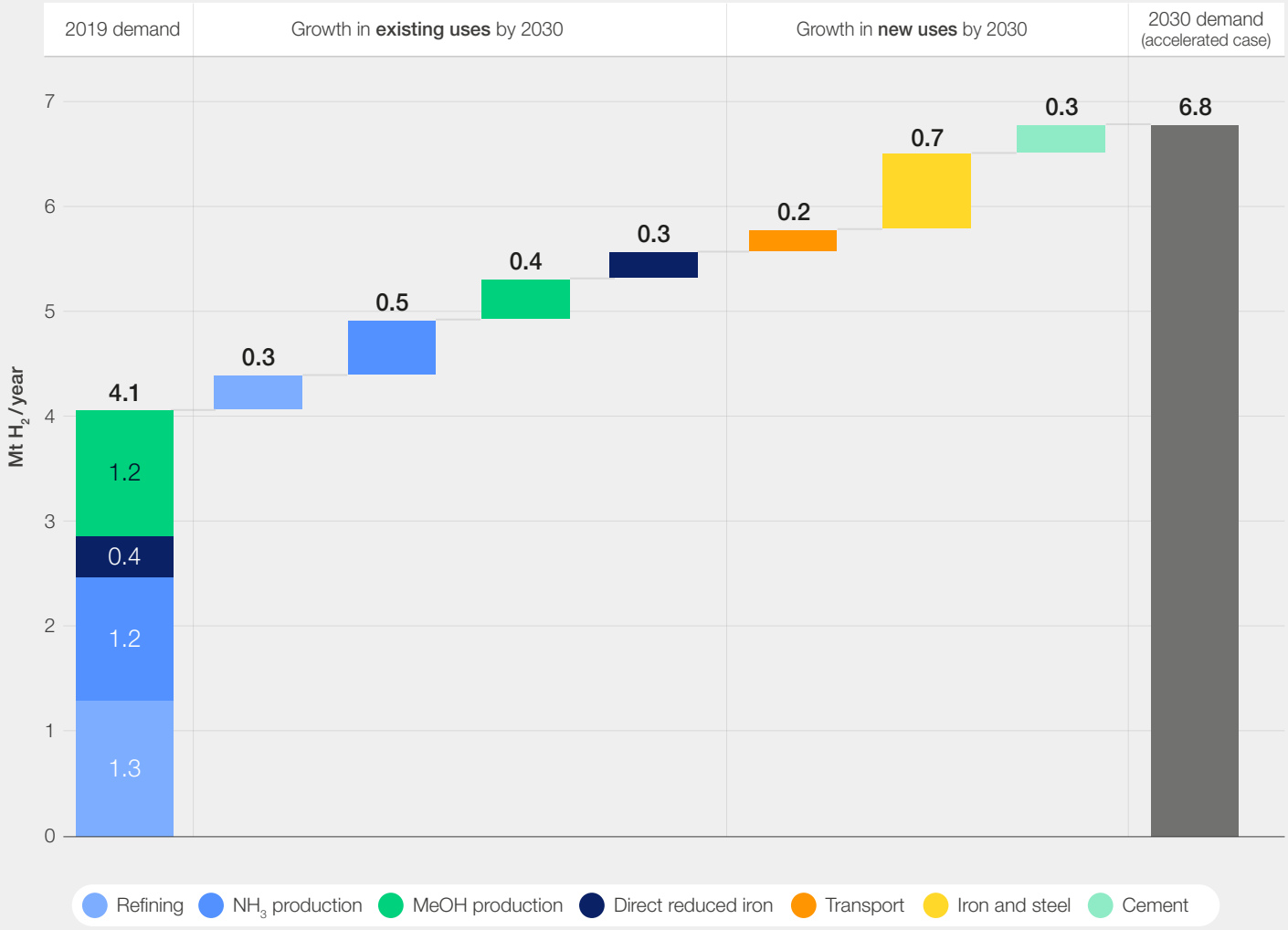
Local decarbonizers:

- Insufficient local demand will prevent the acceleration of these countries' domestic clean hydrogen economies.
- Local decarbonizers need to understand the challenges that hard-to-abate industries face in developing clean hydrogen adoption. The required acceleration in switching local demand from conventional/grey hydrogen to clean hydrogen must come from growth in existing uses (e.g. refining, ammonia, methanol), as well as from the development of new uses (e.g. transport, iron and steel, cement) – see Figure 10.

Focused players:

- In the case of focused players, there is high uncertainty around the number and consistency of potential customers and specific use-cases for clean hydrogen, both in the short- and long-term.
- Given that the adoption of technologies that enable the use of clean hydrogen requires investment from customers to adapt their existing assets and/or machinery, frictions around this process could impede the growth in demand for clean hydrogen.

FIGURE 10 | **Hydrogen demand in Latin America, million tonnes (Mt), 2019-2030**



Notes: NH_3 = ammonia, MeOH = methanol.

Source: IEA, 2021.[33]

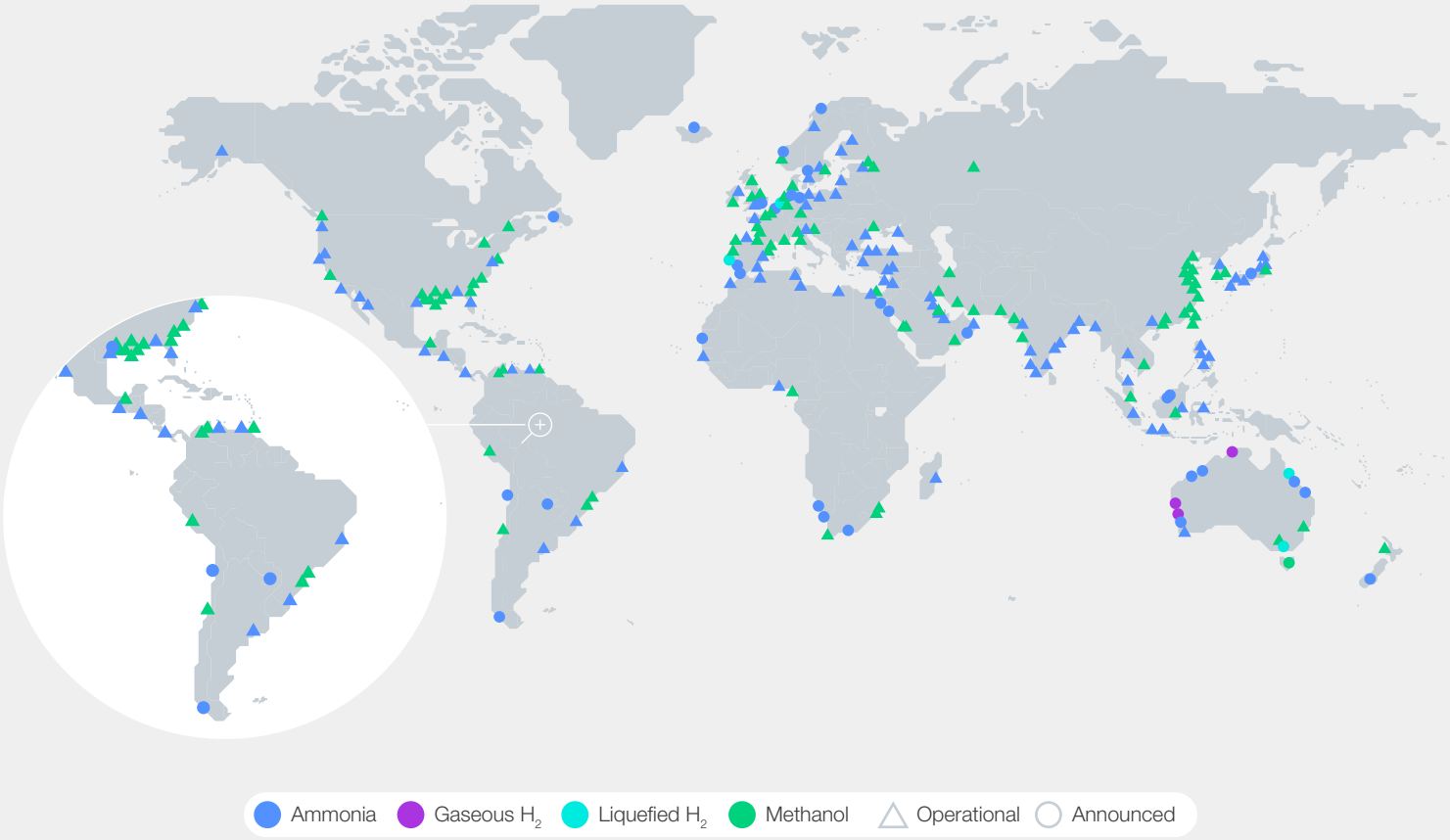
Infrastructure

Current and new uses of hydrogen require infrastructure and technology development. There is a significant lack of dedicated infrastructure for the transportation and storage of clean hydrogen, posing a key obstacle for the industry's development. Moreover, with the projected rising demand for clean hydrogen across various sectors in upcoming decades, the development of broader clean hydrogen transport networks, potentially cross-border, will be necessary to meet this growing demand.[34]

Net exporters:

- Net exporters need to develop dedicated infrastructure for clean hydrogen exports (e.g. with regard to transportation technologies and ports).
- Latin America has an immature clean hydrogen infrastructure that needs to be developed and scaled-up. Transportation infrastructure is one of the biggest challenges countries face to fully develop their clean hydrogen value chains.
- Existing infrastructure can provide a basis to begin developing the clean hydrogen value chain: for example, Latin America has numerous operational and announced port infrastructure projects for trading ammonia and methanol (see Figure 11). However, this will not be sufficient to fulfil the future needs of the clean hydrogen economy.
- Although Latin America can leverage its existing oil and gas (O&G) infrastructure and retrofit for hydrogen transportation, the feasibility of these changes and its cost efficiency is still to be tested and depends largely on technology development.

FIGURE 11 | **Global existing and announced port infrastructure projects for clean hydrogen and hydrogen-based fuel trade**



Source: IEA, 2023.[35]

Local decarbonizers:

- Local decarbonizers face significant challenges due to the lack of centralized infrastructure to easily integrate the clean hydrogen value chain.
- This hinders the scalability and cost-effectiveness of clean hydrogen projects in the region, impeding the sector's potential to contribute to decarbonization efforts and sustainable development.

Focused players:

- Focused players need to adapt their existing infrastructure for clean hydrogen production to maximize their current advantages, which may include beneficial geographic location or industry strengths (e.g. maritime and aviation).
- These adaptations are necessary to enable efficient production, transportation and storage of clean hydrogen, as well as to facilitate its integration into other sectors. Any adaptations of existing infrastructure will need to comply with global quality and safety standards.
- Significant challenges include assessing the feasibility of adapting existing infrastructure as well as addressing the absence of suitable infrastructure.

Pace of development

Greater coordination between ecosystem actors is needed to drive economies of scale and accelerate the development of the clean hydrogen economy.

Net exporters:

- Lack of collaboration between key actors in export markets is hindering project acceleration and the establishment of offtake agreements.
- An absence of effective coordination between public and private sectors poses a significant challenge to the expansion of the clean hydrogen export economy in Latin America.
- Without strong collaboration, the pipeline of clean hydrogen projects may be blocked by delays in regulatory approvals, difficulties in accessing finance and a lack of clarity around offtake agreements.

“Without strong collaboration, the pipeline of clean hydrogen projects may be blocked by delays in regulatory approvals, difficulties in accessing finance and a lack of clarity around offtake agreements.

– Addressing these challenges and fostering a cohesive partnership between the public and private sectors are crucial to accelerate the development and deployment of clean hydrogen initiatives, enabling Latin America to fully leverage its potential as an exporter.

Local decarbonizers:

– Local decarbonizers require different actors to coordinate across the value chain to accelerate the integration of clean hydrogen into key industries.

– Countries face a challenge in synchronizing action across different players in the value chain, particularly between suppliers, current and future industry offtakers and policy-makers. Achieving coordination requires strategic planning, regulatory support and timely investments.

Focused players:

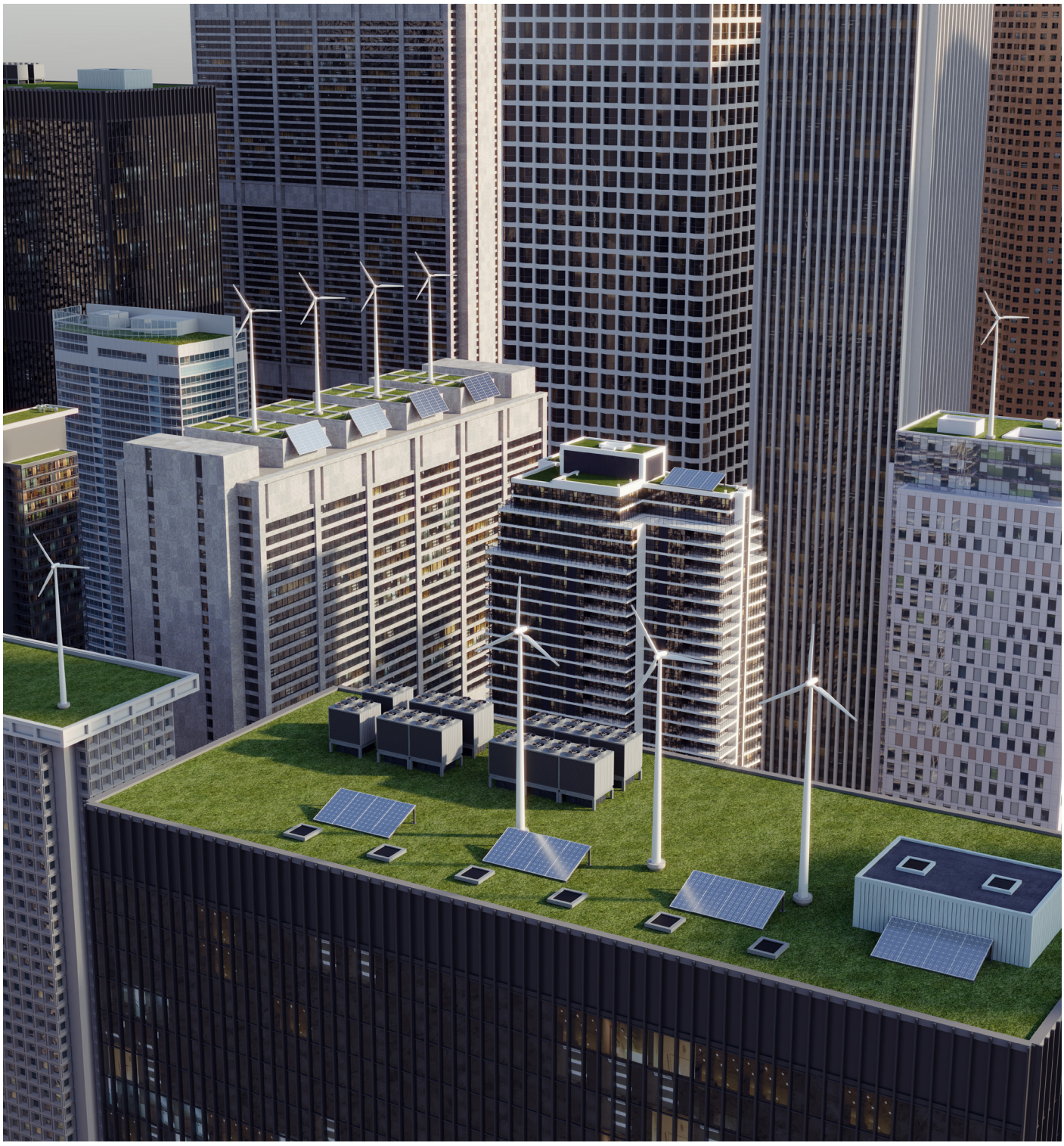
– Given these countries target specific markets or stages of the clean hydrogen value chain, it is critical for them to design and deliver competitive value propositions to potential offtakers.

– Overcoming technical and infrastructure barriers for safe and efficient clean hydrogen production, as well as securing sufficient investment, are key obstacles that must be addressed.

– Greater attention must be given to the essential task of building collaboration among stakeholders, including maritime and aviation companies, technology providers, regulatory bodies and investors.

3 Enabling measures for Latin America

To overcome current challenges and pivot from piloting to execution at scale, key enabling measures need to be prioritized.



3.1 Roadmap of enabling measures

Using the World Economic Forum's *Accelerating Clean Hydrogen Framework,* Chapter 2 identified existing barriers and challenges facing the development of the clean hydrogen economy across the region. This chapter presents a roadmap of enabling measures that can be classified into four categories (see Figure 12):

- Technology evolution and R&D
- Standards and certification
- Markets and financing
- Matching supply and demand

The enabling measures provide key actions and initiatives to help public and private players overcome the region's cross-cutting challenges, such as technology and talent, cost, standards and certification, and the barriers that are more specific to each of the three pathways – infrastructure, demand and pace of development.

Figure 13 presents the six barriers, frames objectives to overcome each barrier and details the enabling measures required to achieve those objectives.

FIGURE 12 **Categories of enabling measures**

Note: Within the four categories, items are examples and not exhaustive.

FIGURE 13 | **Roadmap of enabling measures to accelerate Latin America's clean hydrogen economy**

Barrier	Objective	Enabling measures		
Enabling measures type: Technology evolution and R&D · Standards and certifications · Markets and financing · Matching supply and demand				
Standards and certification 	Ensure clarity on technical, safety and carbon intensity standards and certifications. (All pathways)	1a. Promote regional agreements and partnerships to standardize regulations.	1b. Define technical standards for the clean hydrogen production value chain (e.g. transportation, storage, conversion).	1c. Define technical standards for clean hydrogen derivatives (e.g. ammonia, synthetic fuels).
		1d. Create industrial safety and security standards and workforce training systems for whole clean hydrogen value chain.	1e. Define technical standards for new parts of the value chain beyond production (e.g. infrastructure).	
Cost 	Reduce or eliminate costs related to hydrogen conversion, storage and transport. (All pathways)	2a. Decrease investment costs for renewables, electrolysers and CCS with dedicated support.	2b. Unify multiple funds available as a one-stop-shop (e.g. fiscal incentives, funds to ease additionality rules for first movers and to cover cost gap of clean hydrogen production).	2c. Encourage collaboration to share renewables and CCS resources between nearby industries and/or among clusters to lower costs.
Technology & talent 	Focus innovation and R&D to enable technology scale-up. (All pathways)	3a. Redirect R&D investment from O&G to clean hydrogen; establish R&D centres to ensure scale-up of new technology.	3b. Identify critical skills and develop strategy to ensure highly qualified workforce is available.	3c. Increase funding for clean hydrogen-related research and encourage public-private partnerships.
Demand 	Develop international demand and offtakers. (Net exporters)	4a. Boost global collaboration and alignment with relevant clean hydrogen market design and rules (including for derivatives).	4b. Guarantee stable international demand using signed long-term agreements with offtakers.	
	Drive strong local clean hydrogen demand. (Local decarbonizers)	5a. Enable better tracking/traceability on allowed carbon intensities/emissions to drive industry demand for clean hydrogen.	5b. Establish robust industrial clusters (e.g. public sector, energy producers, technology providers and investors) to drive decarbonization in key sectors.	5c. Focus incentives on sectors with high energy consumption and significant emissions, such as heavy industry, transportation and power generation.
	Boost demand from the sector served. (Focused players)	6a. Identify high-value/efficient applications, including derivatives, and define targets by end-use sector.	6b. Sign MOUs and commercialization agreements with target sectors.	
	Drive major clean hydrogen projects to ensure enough supply. (All pathways)	7a. Initiate extensive public-private, private-private and public-public partnerships for clean hydrogen development.	7b. Incentivize the development of clean hydrogen valleys/hubs through promotion of regional and sectoral targets.	7c. Promote an increase in demand by developing technology for new uses of clean hydrogen (e.g. transportation, iron and steel).

FIGURE 13 | **Roadmap of enabling measures to accelerate Latin America's clean hydrogen economy** (continued)

Barrier	Objective	Enabling measures		
Enabling measures type: Technology evolution and R&D · Standards and certifications · Markets and financing · Matching supply and demand				
Infrastructure 	Develop dedicated infrastructure for clean hydrogen exports. **(Net exporters)**	**8a.** Develop dedicated clean hydrogen export infrastructure, including ports and shipping capabilities.	**8b.** Establish clean hydrogen hubs, focusing on areas near major industrial centres or ports to facilitate exports.	**8c.** Incentivize the construction of clean hydrogen infrastructure with funding and capacity payments.
	Create a centralized infrastructure for clean hydrogen. **(Local decarbonizers)**	**9a.** Establish clean hydrogen hubs in strategic locations to streamline production, distribution and internal consumption processes.	**9b.** Plan to retrofit existing O&G infrastructure with required clean hydrogen infrastructure (e.g. pipelines, storage, usage).	**9c.** Specify interoperable quality standards and definitions to enable integration with existing infrastructure.
	Adapt and reuse infrastructure for specific uses. **(Focused players)**	**10a.** Drive connecting and planning of localized refuelling stations.	**10b.** Collaborate with stakeholders for optimal distribution of production and consumption sites to ensure required supply chain infrastructure evolves.	
Pace of Development 	Accelerate pace of hydrogen scale-up and development to drive economies of scale. **(Net exporters)**	**11a.** Drive automation of electrolyser production and increase raw material efficiency.	**11b.** Provide innovative financing mechanisms to enable high capital investments required to develop clean hydrogen technology and infrastructure.	**11c.** Co-develop infrastructure internationally and promote knowledge exchange.
	Coordinate ecosystem. **(Local decarbonizers)**	**12a.** Develop and publicize dedicated clean hydrogen strategy (ensure sector-specific production, infrastructure and end-use targets are aligned).	**12b.** Orchestrate different actors across value chain anchored by industrial clusters.	**12c.** Establish robust but flexible regulatory frameworks to clarify clean hydrogen terminology, plus well-defined rules and incentives along value chain.
	Design and test the value proposition. **(Focused players)**	**13a.** Design and test value proposition to potential clients, while actively involving them in co-creation process.	**13b.** Execute detailed studies of potential demand of target sector/ product and its growth projection, to plan hydrogen production capacity around demand forecasts.	

3.2 Key success factors: regional collaboration and coordination

Regional collaboration and coordination will be essential to successfully execute the different enabling measures needed to accelerate the clean hydrogen economy in Latin America. Unlike in the EU or US, where there is centralized leadership to help countries or states coordinate their efforts, Latin America requires an innovative approach towards building effective collaboration between different countries to capture the benefits of a regional approach.

The following success factors, outlined below, showcase the importance of both regional and international collaboration and coordination, and should be considered when planning and executing the region's journey towards a clean hydrogen economy:

- Identify regional synergies and opportunities to work together.
- Develop and align on regulatory frameworks and certification schemes.
- Foster global cooperation and sharing of insights.
- Pursue an inclusive clean hydrogen economy pathway.
- Support citizens as the clean hydrogen economy emerges.

Identify regional synergies and opportunities to work together

In an industry that requires enormous scale and investment, working collaboratively can help distribute both effort and risk, as well as create market consolidation and stability by aggregating regional supply and demand.

To this end, the Transitioning Industrial Clusters initiative of the World Economic Forum, created in collaboration with Accenture and the US-based Electric Power Research Institute (EPRI), has improved cooperation and common vision between co-located companies and governments to drive economic growth, employment and the energy transition.

This industrial cluster approach can accelerate the clean hydrogen economy by:

- Aggregating demand – reducing offtaking risk.
- Creating shared infrastructure – reducing individual investments and improving access to financing and grants.
- Enabling development of larger projects – leveraging economies of scale.
- Providing a global forum, where clusters can learn from others and replicate successful models.

Collaboration is also key at a regional level:

- For technology and infrastructure development, the identification of high-level R&D opportunities of mutual interest based on complementary strategies can reduce duplicated efforts and accelerate progress through the creation of bilateral or multilateral research collaborations.[36]
- It can help improve the region's visibility, strengthen its negotiating position with international offtakers, and promote it as an important clean hydrogen production hub, enabling it to attract greater external investment and additional support.

Develop and align on regulatory frameworks and certification schemes

Global and regional collaboration are important to ensure an effective clean hydrogen regulatory framework and certification process. Learning from existing regulatory frameworks, such as the EU's, can offer ideas and opportunities. Collaboration between countries in the region could help ensure existing frameworks are adapted to the Latin American context.

A relevant example of regional collaboration in Latin America is CertHiLAC – a joint effort between the Inter-American Development Bank (IDB) and the Latin American Energy Organization (OLADE) to create a certification system for clean hydrogen production in Latin America and the Caribbean. It was launched in November 2023 and already more than a dozen countries have signed up.

Given that most clean hydrogen demand will be met through international trade, the coordination of standards and alignment of certification is vital to guarantee compliance around rules of origin and sustainability practices. However, while a global homogeneous certification scheme is preferable, it could take considerable time to develop. In the meantime, strong international and regional cooperation is needed, through initiatives that provide transparency and limit divergence between standards.[37]

Foster global cooperation and sharing of insights

By playing an active role in global clean hydrogen communities and industry groups, countries can help foster an in-depth understanding of global challenges and bottlenecks hampering the development of the clean hydrogen economy. Sharing best practices and lessons learned is an important priority to help countries resolve bottlenecks and find innovative solutions to address current challenges.

Latin American countries should seek to participate in global collaboration networks and technology efforts to accelerate the global market. Opening up spaces for dialogue with global partners could provide Latin American countries with a platform to advocate for special requirements, such as innovative financing mechanisms or policies, and to seek support through multilateral organizations or partnerships with other nations.[38]

Pursue an inclusive clean hydrogen economy pathway

At a national and regional level, it is important to involve all relevant stakeholders who could be affected by the development of the clean hydrogen economy. It is crucial to convene ministries, industry and businesses, financial institutions, academic and research organizations, local communities and NGOs to share their perspectives, concerns and needs in order to ensure an inclusive and sustainable transition.[39]

Support citizens as the clean hydrogen economy emerges

Public acceptance is critical for the adoption of new technologies, as it provides a social licence to operate in new ways. Latin American countries should launch public awareness campaigns to inform citizens about the benefits of clean hydrogen, including its role in reducing emissions and creating jobs. Engaging with communities to address their concerns and highlight local benefits is an important priority to gain public acceptance for major new projects and will help accelerate clean hydrogen development across the region.

Conclusion

To accelerate the clean hydrogen economy in Latin America, targeted action and collaboration are needed not just locally, but regionally and internationally.

Latin America has the potential to be a competitive player in the global clean hydrogen economy. Its access to vast renewable energy resources positions it to become a net exporting region in the long term. Along with its potential role in decarbonizing regional economies, clean hydrogen also provides an opportunity to foster social and economic growth.

This report has presented three distinct clean hydrogen pathways that countries in the region are likely to follow, each with its own specific objectives, challenges and enabling measures. Some countries will focus initially on exporting most of their production ("net exporters"); some will look to prioritize the development of their domestic clean hydrogen demand to decarbonize their economies ("local decarbonizers"); and some will follow a targeted, sector-based approach, using clean hydrogen to complement existing solutions ("focused players").

By prioritizing enabling measures specific to their pathways, countries can move rapidly from planning to action at scale. For example:

- **Net exporters** should focus on advancing international offtake agreements to guarantee stable demand, as well as accelerating the construction of dedicated transportation and port infrastructure.
- **Local decarbonizers** should leverage industrial clusters to promote the integration of the clean hydrogen value chain for large-scale projects. Clusters can help build connections between supply and demand, create economies of scale through shared infrastructure and distribute risks.
- **Focused players** should engage with potential sector-specific offtakers to understand how clean hydrogen can fulfil their needs and how best to adapt existing infrastructure to serve those needs.

Underpinning these measures, Latin American countries must bear in mind the key success factors outlined in this report, including: identification of regional synergies and opportunities to work together; fostering cooperation and collaboration; obtaining community buy-in; and sharing lessons learned from countries at more advanced stages of maturity. These factors will prove essential in accelerating progress towards addressing mutual challenges and bottlenecks.

Above all, to deploy the success factors outlined in this report effectively, countries must seek collaboration and coordination across the region and internationally.

The World Economic Forum, in collaboration with Accenture and other partners, will continue to support the development of the clean hydrogen economy in Latin America, through strategic initiatives such as the Transitioning Industrial Clusters (TIC) initiative and the Mobilizing Investment for Clean Energy in Emerging Economies (MICEE) initiative to enable collaborative actions to scale-up clean energy finance in emerging and developing markets.

Appendix: Country profiles

Seven countries were selected as high-potential players in the clean hydrogen economy in Latin America.

Methodology for country selection

Five indicators were considered to identify the seven countries that should be prioritized for this analysis and to understand the current and potential maturity of the clean hydrogen industry in the region, as well as the enablers available to accelerate its development (see Box 2 and Figure 14).

BOX 2 **Five indicators to select countries and the underlying criteria**

Strategy
Clean hydrogen strategy, ambition and policy extent.

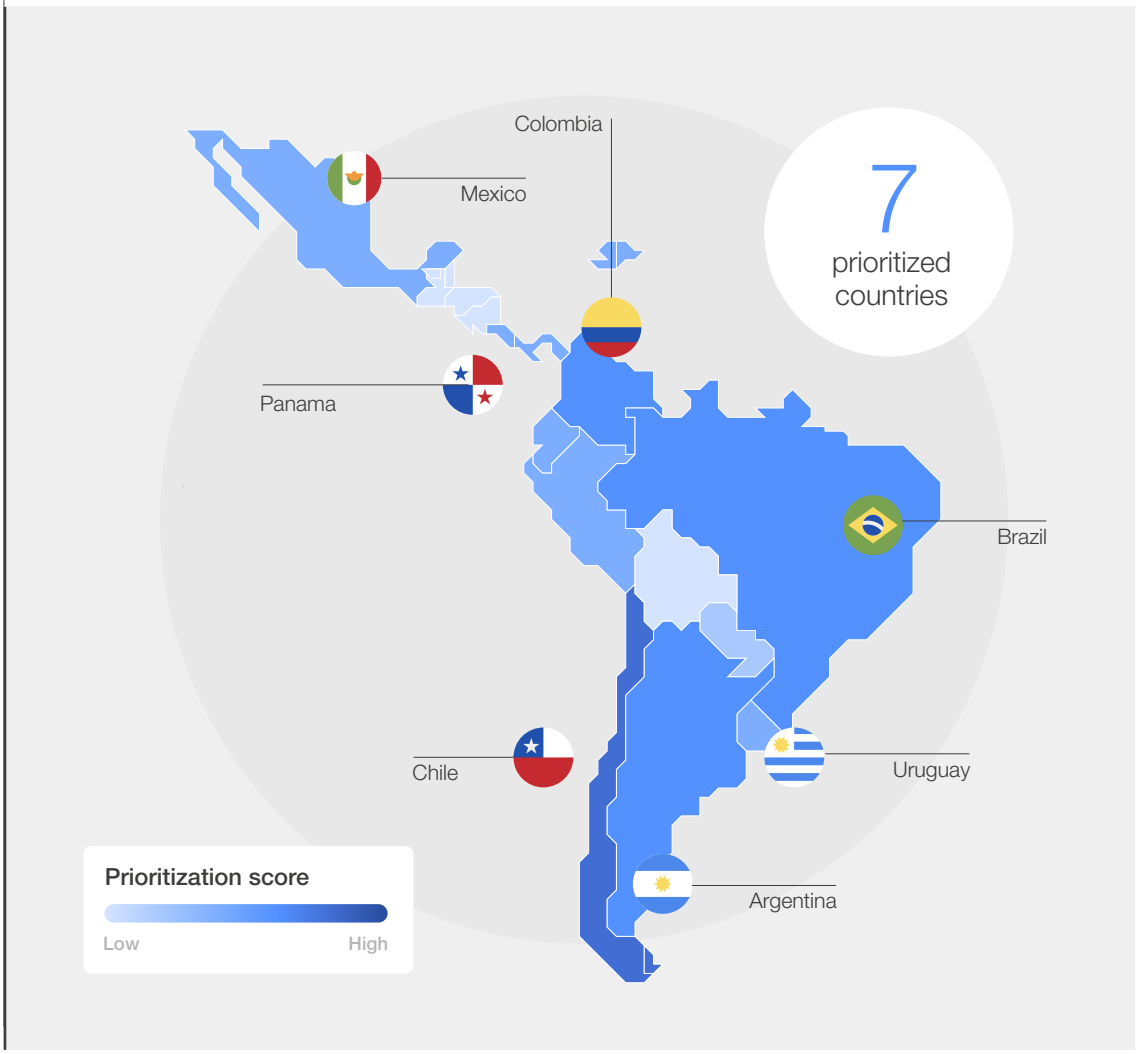
Materiality
Projected production volumes, projected demand for clean hydrogen, current use of hydrogen (conventional/grey + clean) and expected market value.

Current projects
Number of projects currently underway promoting development of clean hydrogen industry.

Infrastructure
Projected infrastructure for the production and transportation of clean hydrogen (e.g. electrolyser capacity, maritime port readiness).

Investment
Announced investments for clean hydrogen projects as well as a consideration of projected public-private investment.

FIGURE 14 **Country prioritization scoring map**



Following country selection, clean hydrogen-readiness assessments were conducted for each country. These assessments included an analysis of the state and maturity of the entire clean hydrogen value chain, considering variables such as targets, policies, preliminary accelerators and barriers. The assessments in turn provided the basis for developing a policy and funding landscape analysis for each of the seven countries, providing a clear picture of the present and potential future clean hydrogen economies across the region. This country-by-country landscape analysis is presented below.

Notes on data

1. Levelized costs of hydrogen (LCOH) detailed below for each country are projections and do not necessarily correspond to the real cost of production. This is because existing clean hydrogen projects are mostly pilots and there are currently no large-scale projects in operation.

2. Production volumes detailed below for each country are based on country statements and are often goals rather than precise estimations, leading to potential deviations from production numbers stated in previous chapters.

COUNTRY PROFILE

Argentina

Population
45.8 million (2023)

GDP
$631 billion (2022)

GDP per capita
$13,709

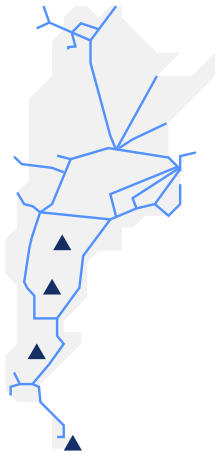
CO_2e emissions
382.9 Mt (2022)

Installed renewable capacity[40]
15 GW

Natural gas production
140 million m³ (2023)

Ammonia imports (value)
$225,000 (2021)

Current infrastructure[41,42]



— Gas pipelines

▲ Ports

Facts and figures

Source: Argentina Presidency.[43]

Today

LCOH/kg:
SMR+CCS/Blue: $1.10-$2.10
Renewable/Green: $2.80-$6.40

Current H_2 demand/yr:
0.4 Mt

Demand focused on:
Fertilizers, refining, steel industry, methanol and other chemicals

2030

LCOH/kg:
SMR+CCS/Blue: $1.10
Renewable/Green: $1.70

Domestic H_2 production/yr:
Goal of 1 Mt by 2035

Expected local demand:
0.02 Mt of clean H_2
Exports of 0.3 Mt

2050

LCOH/kg:
SMR+CCS/Blue: $1.10
Renewable/Green: $1.40

Domestic H_2 production/yr:
Goal of 5 Mt of clean H_2
– 20% (1 Mt/yr) will be designated for the local market
– remaining 80% (4 Mt/yr) will be for export

Current advancements in enabling measures[44]

Standards and certifications

Argentina is set to implement a certification of origin system by 2030, based on emissions criteria, free of technological bias and aligned to adopting markets. In 2023, the "Promotion of Low Carbon Hydrogen and Other Greenhouse Gas Emissions" bill was presented to the congress, aiming to support clean hydrogen projects. Additionally, the Energy Secretariat plans to develop a certification framework for clean hydrogen.

Cost

Argentina is launching pilot-scale projects to assess hydrogen production costs, aiming to clarify expenses and remove barriers. The "Promotion of Low Carbon Hydrogen and Other Greenhouse Gas Emissions" bill proposes tax breaks, access to foreign currencies and allocation of revenue for international funding. The strategy includes seeking strategic partners for pilot plants and participating in bids for supply contracts. Additionally, the voluntary green bond market provides an opportunity for hydrogen sector companies and small investors to support environmentally focused projects.

Technology and talent

Argentina is prioritizing the advancement of critical technologies like electrolysis and CCUS for clean hydrogen production through technology transfer and innovation. Efforts include promoting research, establishing dedicated research centres and fostering technological start-ups. These initiatives are expected to create 13,000 jobs by 2030 and 82,000 by 2050, with a focus on technical and professional training in hydrogen-related topics through collaboration between government sectors and universities.

Demand

Argentina plans to stimulate demand for synthetic fuels such as methanol, sustainable aviation fuel (SAF) and hydrotreated vegetable oil (HVO – a renewable diesel fuel), relying on clean hydrogen, particularly to decarbonize maritime and aeronautical transport. Additionally, the country aims to facilitate hydrogen demonstration projects by implementing controlled regulatory environments known as "sandboxes".

Infrastructure

Argentina is progressing in its clean hydrogen sector, with nine ongoing projects and seven in the pipeline. By 2030, Argentina aims to transition several projects from concept to operational stages. Private initiatives, leveraging renewable resources for electrolysis, are driving this development, supported by collaborations with international institutes and investments in renewable energy sources.

Pace of development

Argentina aims to master alkaline electrolysis technology by 2030, facilitating knowledge transfer and serial production. Pilot projects are underway to gauge hydrogen production costs and enable clearer understanding, while controlled regulatory environments are being established to make hydrogen demonstration projects feasible.

COUNTRY PROFILE

Argentina

Public policies, partnerships and funding overview[45]

Policies

- Overarching strategic vision
- Policy framework
- Legislation

National Strategy for the Development of the Hydrogen Economy

National Strategy for the Development of the Hydrogen Economy-Action Plans

Strategic Environmental Assessment

Bill: Promotion of Low Carbon Hydrogen and Other Greenhouse Gas Emission
– promotes clean hydrogen production projects

Law 25675 of 2002: General Environmental Law
– sets minimum budgets for achievement of sustainable development

Law 26123 of 2006:
Regime for the development of technology, production, use and applications of hydrogen as fuel and energy vector

Law 27191 of 2015:
National Promotion Regime for the Use of Renewable Energy Sources to Produce Electric Energy (modification)

Law 27566 of 2020:
Escazú Agreement

Partnerships and funding

- Financial instruments
- Partnerships

Creation of Renewable Energy Law (27.191)
– to finance clean-source energy projects[46]

RenovAR
– an auction-based renewable energy programme designed to scale-up private renewable generation capacity[47]

$480 million World Bank guarantee
– to boost private investment in Argentina's renewable energy sector[48]

$350 million Inter-American Development Bank loan
– to drive sustainable and resilient growth in Argentina[49]

H2ar Consortium[50]
– offers a collaborative workspace for companies interested in participating in the hydrogen value chain

MoU between European Union and Argentina
– to advance cooperation and achieve objectives in clean energy, mainly in areas of hydrogen[51]

Projects between Argentina and Germany
– in the field of energy transition/ green energy, to stimulate sustainable relations[52]

COUNTRY PROFILE

Brazil

Population
216.4 million

GDP
$1.92 trillion (2022)

GDP per capita
$9,455

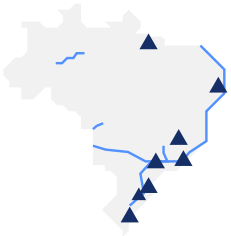
CO_2e emissions[53]
1,310.5 Mt (2022)

Installed renewable capacity
175.3 GW

Natural gas production
48.8 billion m^3 (2021)

Ammonia imports (value)
$259 million (2021)

Current infrastructure[54,55]



— Gas pipelines

▲ Ports

Facts and figures

Today

LCOH/kg:
Renewable/Green: $2.87-$3.56 (2023)[56]

Current H_2 demand/yr:
0.4 Mt (2019)[57]

– currently limited to oil refining and ammonia production, potential expansion to steel and fertilizers for decarbonization

2030

LCOH/kg:
Renewable/Green: ~$1.90[58]

Domestic H_2 production/yr:
Potential for 0.6-1.1 Mt[59]

– 60% of total renewable/green H_2 supply is expected to be consumed domestically[60]

2050

LCOH/kg:
Renewable/Green: ~$1.20[61]

Domestic H_2 production/yr:
Potential for 21-32 Mt[62]

– Brazil will compete in clean hydrogen, accounting for 10% of the global market

– exports of 4 Mt produced via electrolysis

Current advancement in enabling measures

Standards and certifications

Brazil is one of the leading countries in the region, working to establish a strong regulatory framework for green/renewable hydrogen, spearheaded by organizations such as the Brazilian Green Hydrogen Industry Association (ABIHV)[63]. Furthermore, the Electric Energy Commercialization Chamber (CCEE) is developing a renewable energy certificate for clean hydrogen, which can be blended into natural gas to help lower the industry's carbon footprint.[64]

Cost

The country has several public policies and financial mechanisms to increase the competitiveness of clean hydrogen, including tax relief, special financing conditions, green finance and dedicated funds for renewables. Furthermore, Brazil has leveraged international funding and partnerships to overcome high costs, including a €2 billion investment from the EU as part of the Global Gateway initiative, BRL 21 million from a Brazil-Germany agreement for renewable/green hydrogen projects and a World Bank collaboration for solar power and renewable/green hydrogen development in north-eastern states.[65]

Technology and talent

The Brazilian government has committed to investing approximately BRL 200 million per year by 2025 into clean hydrogen R&D, including the creation of clean hydrogen pilot plants in all regions of the country by 2025 and the establishment of clean hydrogen hubs in Brazil by 2035.[66]

The Brazilian Ministry of Mines and Energy (MME), in collaboration with the National Service for Industrial Training (SENAI) and Germany's international development agency GIZ, has signed a cooperation agreement for the creation of the first Green Hydrogen Centre of Excellence in Natal (RN), together with five regional educational and training centres in the field of renewable/green hydrogen (known in Brazil as "H_2V").[67] Partnerships with academia and research centres would help overcome technological challenges around clean hydrogen.

Demand

Through the National Hydrogen Program, Law No. 21767 of 2023 – State of Paraná[68] and the Brazilian Pact For Renewable Hydrogen,[69] Brazil is working to promote clean hydrogen applications such as a clean energy source or for use in the production of agricultural fertilizers.

Infrastructure

Brazil is advancing in its clean hydrogen economy with two operational hydrogen projects utilizing renewable sources, while it has an additional 20 projects in various stages of development. Brazil has not set explicit investment goals for 2030, but the scale of ongoing projects indicates substantial private sector investment, complemented by public sector support where needed.

The country has strong commitments towards energy transition that could work as enablers for the evolution of clean hydrogen.

COUNTRY PROFILE

Brazil

Pace of development

Brazil's National Energy Plan 2050 provides a long-term framework for the energy transition. The Brazilian Pact for Renewable Hydrogen sets ambitious goals but lacks specific timelines or quantifiable targets.[70,71] Nevertheless, Bill No. 725 of 2022 aims to expedite energy sector development through regulatory clarification, complemented by Decree No. 21200 which establishes a strategic plan, as well as Decree No. 5416 which proposes public policies.

There is an opportunity for creating a smart regulation sandbox which enables technological routes, establishes and incentives the demand side and fosters competition to benefit the consumer.

Public policies, partnerships and funding overview

Policies[72]

- Overarching strategic vision
- Policy framework[75]
- Legislation

National Energy Plan 2050[73]

National Hydrogen Program (PNH2)[74]

Bill No. 725 of 2022: Addition of hydrogen as an energy source

Bill No. 3173 of 2023: Foster the production, distribution and use of renewable/green hydrogen generated

Decree No. 21200 of 2022: State of Bahia

Law No. 21767 of 2023: State of Goiás

Decree No. 5416-R of 2023: State of Espírito Santo

Law No. 21767 2023: State of Paraná

Law No. 21454 of 2023: State of Paraíba

Brazilian Pact for Renewable Hydrogen[76]

Development of a renewable energy certificate for renewable/green hydrogen[77]

Partnerships and funding

- Financial instruments[78]
- Partnerships

€2 billion investment from European Union – to support renewable/green hydrogen production[79]

BRL 21 million from Germany and World Bank – for renewable/green hydrogen projects[80]

$100 million from World Bank – for Pecém Port as renewable/green hydrogen hub with Ministry of Development and Foreign Trade[81]

Vale and Petrobras protocol of intentions – to increase clean hydrogen demand for green steel production, refining and other clean solutions[82]

Green Energy Park and State of Piauí letter of intent – creation of a 5 GW green ammonia production and export facility[83]

MME-GIZ-SENAI cooperation agreement – creation of the First Centre of Excellence on Renewable/Green Hydrogen[84]

ENGIE and ABH2 partnership – to accelerate business in the renewable/green hydrogen segment[85]

Brazil-Netherlands maritime corridor – to facilitate renewable/green hydrogen exports[86]

COUNTRY PROFILE

Chile

Population
19.6 million

GDP
$301.3 billion (2022)

GDP per capita
$13,355

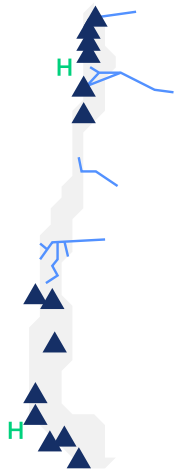
CO_2e emissions[87]
137 Mt (2022)

Installed renewable capacity
17.9 GW

Natural gas production
1.29 billion m^3 (2021)

Ammonia imports (volume)
0.35 Mt (2021)

Current infrastructure[88]



— Gas pipelines

▲ Ports

H Future hubs

Facts and figures

Source: Ministry of Energy Chile[89]

Today

LCOH/kg:
Renewable/Green: $4.50-$5.00

Current H_2 demand:
– focused on refineries, domestic ammonia, transportation (mining, heavy-duty trucks, long-distance buses), gas pipes

2030

LCOH/kg:
Renewable/Green: $1.70-$2.60
– depending on the region

Domestic H_2 production/yr:
Expected ~200,000 tonnes of renewable/green H_2

– expected market size $5 billion/yr ($2 billion domestic demand, $3 billion exports)

2050

LCOH/kg:
Renewable/Green: $0.80-$1.10
– the cheapest in the world

Domestic H_2 production/yr:
Potential for up to 160 Mt of renewable/green H_2

– domestic market for renewable/green H_2 worth ~$33 billion

Current advancement in enabling measures

Standards and certifications

The Chilean government has outlined a regulatory roadmap for the renewable/green hydrogen industry, with clear deadlines for three phases.[90] Regulations for technical aspects of renewable/green hydrogen plants are already in place, while those for environmental compliance and security are under study. Additionally, Law No. 21445 provides a framework for climate change, allowing compliance with emission standards through the acquisition of certificates verifying emission reduction or absorption.

Cost

Chile aims to produce the world's cheapest renewable/green hydrogen by 2050.[91] The country has established a regulatory framework to drive down production costs.[92] It is now accelerating the development of renewable/green hydrogen projects, with significant international support including: a $150 million loan from the World Bank,[93] a $50 million commitment from Chile's economic development agency (CORFO), a €225 million renewable/green hydrogen fund from the European Commission[94] and a $400 million loan from the Inter-American Development Bank.[95]

Technology and talent

Chile has expedited three pilot initiatives for renewable/green hydrogen technology in production, mining and transport, while Germany is investing in technology to accelerate renewable/green hydrogen production in Chile.

The renewable energy industry's expansion in Chile could create 11,000 new jobs.[96] CORFO provided a free online course in 2021 sponsored by the EU to enhance knowledge of the renewable/green hydrogen industry.

Demand

Chile is advancing toward ratifying a trade agreement with the EU, focusing on renewable/green hydrogen, which will facilitate free renewable/green hydrogen trade across borders, boosting demand for Chilean renewable/green hydrogen.[97] Early adoption of renewable/green hydrogen is anticipated in the energy and transportation sectors, particularly for heavy-duty vehicles.[98] Chile projects a market size for renewable/green hydrogen of $5 billion by 2030.[99] Additionally, Santiago's airport aims to incorporate renewable/green hydrogen into its operations to achieve carbon neutrality by 2050, positioning itself as a regional leader in sustainable aviation.[100]

Infrastructure

Chile is making significant strides in its renewable/green hydrogen economy, with 64 projects at various stages of development. Four operational projects utilize technologies like polymer electrolyte membrane (PEM) electrolysis powered by renewable sources. Future projects slated for completion by 2030 range from feasibility studies to large-scale production facilities, showcasing Chile's holistic approach to renewable/green hydrogen integration. The emphasis on dedicated renewables underscores Chile's commitment to sustainable energy solutions.[101]

COUNTRY PROFILE

Chile

Pace of development

Chile's new government in 2022 reaffirmed the ambitious programme for renewable/green hydrogen set by the previous government in the National Green Hydrogen Strategy in 2020.[102] Chile expects to have 5 GW of electrolysis capacity either operating or under development by 2025 and 25 GW by 2030.[103]

Public policies, partnerships and funding overview

Policies

- Overarching strategic vision
- Policy framework
- Legislation[107]

National Green Hydrogen Strategy 2050[104]

Green Hydrogen Action Plan 2023-2030[105]

SAF Roadmap 2050[106]

Development of renewable/green hydrogen regulations

Decree-Law 2224 of 1978 (modified in 2021)
– to directly regulate the renewable/green hydrogen industry

Technical Assessment Criteria in the SEIA*:
– integrated description of projects for the generation of green hydrogen

Bulletin No. 391-369 of 2021

Law No. 20698 of 2013

Law No. 21210 of 2020

Law No. 21455 of 2021

Note: * SEIA is the Chile government's environmental impact evaluation system.

Partnerships and funding

- Financial instruments
- Partnerships

€225 million renewable/green hydrogen fund by Team Europe Renewable in Chile
– for financing renewable/green hydrogen projects[108]

$150 million loan from World Bank
– to promote investment in renewable/green hydrogen projects[109]

$50 million from public funds
– CORFO's commitment to finance the development of six pilot projects[110]

$400 million loan from Inter-American Development Bank
– to finance new projects in renewable/green hydrogen[111]

ENAP* joint-development agreement
– to transform the Gregorio Maritime Terminal into the largest industrial complex in the Magallanes region[112]

BMWK-Siemens Energy**
– developing the world´s first integrated commercial installation to produce climate-neutral fuel near Punta Arenas in south Chile[113]

Notes: * ENAP is Chile's national petroleum company, ** BMWK is the German Federal Ministry for Economic Affairs and Climate Action.

COUNTRY PROFILE

Colombia

Population
52.5 million

GDP
$343.9 billion (2022)

GDP per capita
$6,630 (2022)

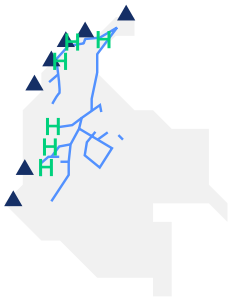
CO_2e emissions[114]
215.5 Mt (2022)

Installed renewable capacity
13.4 GW (2023)

Natural gas production
12.4 billion m^3 (2022)

Ammonia imports (value)
$30.4 million (2021)

Current infrastructure[115, 116, 117]



— Gas pipelines

▲ Ports

H Future hubs

Facts and figures

Source: Ministry of Mines and Energy Colombia[118]

Today

LCOH/kg:
SMR+CCS/Blue: $2.40 (2020)
Renewable/Green: $2.10-$4.80 (2020)

Current H_2 demand:
150,000 tonnes of conventional/grey H_2

– focused on refineries, chemical industry, steelmaking and other industrial uses

2030

LCOH/kg:
SMR+CCS/Blue: $2.40
Renewable/Green: $1.70-$2.70

Domestic H_2 production/yr:
Goal to develop 1-3 GW of electrolysis capacity and produce at least 50,000 tonnes of SMR+CCS/blue H_2

– clean H_2 demand expected to reach 120,000 tonnes (including partial replacement of grey H_2 and new uses)

2050

LCOH/kg:
SMR+CCS/Blue: $2.40-$2.50
Renewable/Green: $1.10-$1.70
– 4th cheapest in world

Domestic H_2 demand:
Estimated at ~1.85 Mt for clean H_2

– transport sector 64%
– industrial sector 34%
– electricity sector 2%

Current advancement in enabling measures

Standards and certifications

Phase 1 of the country's clean hydrogen roadmap focuses on designing guarantees and certifications for renewable/green hydrogen production. This involves collaboration with international task forces to adopt best practices and develop a national certification system. Colombia plans to design a guarantee of origin (GO) system to determine certification mechanisms, actors involved, governance framework and validation processes at local and international levels.[119] Recommendations for implementing a clean hydrogen certification system were provided by energy transition consultancy HINICIO Colombia to the Ministry of Mines and Energy.[120]

Cost

The Colombian government has implemented Law 2099 to incentivize investment in clean hydrogen production and provide benefits. The Mining and Energy Planning Unit (UPME) certifies projects for access to these incentives. Additionally, government investment through the Non-Conventional Energy and Efficient Energy Management Fund (FENOGE) now includes financing for viable projects in the clean hydrogen value chain, prioritizing those that reduce emissions and create wealth and jobs.[121]

Technology and talent

Colombia supports clean hydrogen projects through various funds which aim to promote regional competitiveness and finance science and technology initiatives. The national clean hydrogen action plan includes initiatives such as promoting clean hydrogen workgroups in universities and business associations as well as potentially establishing a national hydrogen centre for pilot projects.[122]

Demand

The incentives provided by Law 2099 for clean hydrogen production also extend to end uses, stimulating demand by reducing costs. Additionally, Law 1964 of 2019 acknowledges clean hydrogen technologies in the mobility sector, offering incentives for electric vehicles (EVs).[123] Law 1931 of 2018 recognizes the role of the Non-Conventional Energy Sources Law in mitigating GHG emissions, prompting local governments to include provisions for promoting renewable energy and energy efficiency in their development plans.[124] The National Hydrogen Roadmap aims to attract $2.5-$5.5 billion in investment for clean hydrogen production and demand projects between 2020 and 2030.[125]

Infrastructure

Colombia is actively expanding its clean hydrogen economy, with six potential hubs operational in different regions by 2050, 28 projects at various stages of development and three operational projects with renewable energy sources already in place. Additional projects are slated for completion in the coming years, with some reaching the FID stage or construction stage between 2023 and 2025, while some will be in the feasibility study phase with target dates extending to 2033.

COUNTRY PROFILE

Colombia

Pace of development

Law 2099 of 2021 grants the national government the authority to establish mechanisms to promote clean hydrogen innovation, research, production, storage, distribution and utilization.[126] Additionally, Law 2069 of 2020 establishes a regulatory sandbox for innovative business models in regulated industries.[127] Colombia's national action plan includes creating a centralized registry of clean hydrogen projects and companies to identify interests, project types, synergies and best practices within the clean hydrogen value chain.[128]

Public policies, partnerships and funding overview

Policies

Overarching strategic vision

Policy framework

Legislation

National Hydrogen Roadmap[129]

Certification system recommendations[130]

Law 1715 of 2014
– promotes the development and use of renewable energy sources and their storage systems[131]

Law 2099 of 2021
– encourages the use of renewable/green and SMR+CCS/blue hydrogen[132]

Law 2069 of 2020
– supports entrepreneurial growth and social equity[133]

Decree 2235 of 2023
– modifies Article 235 of Law 2294 of 2023 in relation to the development of natural/white hydrogen* projects[134]

Note: * natural/white hydrogen: formed by natural processes.

Partnerships and funding

Financial instruments

Partnerships

$1 billion loan from World Bank
– to support a programme of reforms aimed at contributing to Colombia's clean hydrogen development[135]

FENOGE
– national fund to finance and execute plans and projects to improve energy efficiency[136]

UK investment
– to develop renewable/green hydrogen and ammonia production projects up to 5 GW[137]

European Union investment
– financing hydrogen projects in Colombia[138]

$750 million low-interest loan from World Bank
– to support efforts towards long-term sustainable growth by promoting key institutional reforms[139]

Ecopetrol and Colombian government
– the government has backed plans for investment in renewable energy and clean hydrogen projects[140]

MoU with Medellín Public Companies (EPM) and Japan Bank for International Cooperation
– to promote the exploration of new opportunities in renewable energy and clean hydrogen projects[141]

Climate partnership with €200 million pledge from Germany
– to help Colombia reach its climate targets[142]

MoU with Fraunhofer Gesellschaft
– to analyse the production of hydrogen, ammonia, methanol and green fertilizers[143]

Dialogues with South Korea
– exploring the potential for renewable/green hydrogen exports[144]

COUNTRY PROFILE

Mexico

Population
129.4 million

GDP
$1.46 trillion (2022)

GDP per capita
$10,077

CO_2e emissions[145]
819.9 Mt (2022)

Installed renewable capacity
31.7 GW

Natural gas production
31 billion m^3 (2022)

Ammonia imports (value)
$340 million (2021)

Current infrastructure[146,147]

Gas pipelines

Ports

Facts and figures

Today

LCOH/kg:
Renewable/Green: ~$4.00[148]

Current H_2 demand/yr:
51,000 tonnes of H_2 by 2025[149]
– demand is driven by refining and petrochemical activity[150]

2030

LCOH/kg:
Renewable/Green: ~$2.75
Estimated onsite production cost

Domestic H_2 demand & production/yr:
~ 230,000 tonnes of renewable/green H_2[151]

2050

LCOH/kg:
Renewable/Green: ~$1.25
Estimated onsite production cost

Domestic H_2 demand/yr:
2.67 Mt of renewable/green H_2 by 2050

Current advancement in enabling measures

Standards and certifications

Mexico is working closely with regional associations to promote the implementation of standards and certification schemes.

Cost

In Mexico, there are currently no legislative incentives for non-electrified hydrogen, although a carbon tax is in place.[152] Research and development in clean hydrogen technologies are funded by both the government and private sector. However, specific financing options for hydrogen projects are lacking. Clean energy certificates (CELs) could potentially offer financial benefits to hydrogen projects if the hydrogen produced is used for energy generation and meets the criteria outlined by the Electricity Industry Law, allowing it to be classified as “clean” energy.

Technology and talent

In Mexico, over 10 researchers across various universities and research centres are actively developing hydrogen technologies, focusing on production, conditioning, re-conditioning and consumption systems.[153] Annually, around 100-130 academic papers are presented at the Mexican Hydrogen Society’s congress. Key institutions leading these efforts include the Polytechnic National Institute (IPN), the Research and Advanced Studies Centre (CINVESTAV), the National Institute of Electricity and Clean Energy (INEEL), the Autonomous National University of Mexico (UNAM), the Electrochemistry Research and Development Centre (CIDETEQ) and the Scientific Research Centre of Yucatan (CICY).[154]

Demand

There are currently no enabling measures in place, however, the Mexican Hydrogen Association (H_2Mex) conducted a study which projected the demand for renewable/green hydrogen in Mexico could be 51,000 tonnes by 2025, 228,000 tonnes by 2030 and 2.67 Mt by 2050.[155]

Infrastructure

Mexico is making strides in the renewable/green hydrogen sector with nine projects, all utilizing dedicated renewable energy sources for hydrogen and ammonia production. Three projects are in the feasibility study stage, with Energía Los Cabos set to be operational by 2024, the Mexican Green Hydrogen Hub phase 1 by 2025 and Delicias Solar by 2026. Two projects, Hy2gen Yucatan phases 1 and 2, are conceptual with a target date of 2028. The remaining four projects are still in the concept stage with unspecified operational dates.

Pace of development

There are currently no enabling measures in place; however, H_2Mex has proposed to start creating the national strategy and an official roadmap with its objectives.[156]

COUNTRY PROFILE

Mexico

Public policies, partnerships and funding overview

Policies

- Overarching strategic vision
- Policy framework
- Legislation

A national strategic vision does not exist yet – the Mexican Hydrogen Association (H2Mex) has proposed creating the national strategy and an official roadmap with objectives

Transition Strategy to Promote the Use of Cleaner Technologies and Fuels[157]

Article 27 of the Political Constitution of the United Mexican States[158]

Law of Energy Transition
– promotes electricity generation coming from clean energies[159]

Electricity Industry Law 2014
– defines clean energy, including clean hydrogen[160]

General Law on Climate Change
– establishes reduction goal for GHG emissions[161]

Partnerships and funding

- Financial instruments
- Partnerships

$122 million invested by H2Gen, GIZ and Mexion
– for the construction of a renewable/green hydrogen facility[162]

Energy partnership between Germany and Mexico
– promotes the development of renewable energy sources[163]

Joint venture between H2V2 Mexico and Mexican H2B2 Electrolysis
– to produce renewable/ green hydrogen[164]

Collaboration agreement with the US Fuel Cell and Hydrogen Energy Association (FCHEA)
– to promote renewable/ green hydrogen in Mexico and the US[165]

COUNTRY PROFILE

Panama

Population
4.46 million

GDP
$76.5 billion (2022)

GDP per capita
$17,357

CO_2e emissions[166]
18.5 Mt (2022)

Installed renewable capacity
2.4 GW (2022)

Natural gas production
Zero (2021)

Ammonia imports (value)
$167,000 (2020)

Current infrastructure[167, 168]

— Gas pipelines

▲ Ports

H Future hubs

Facts and figures

Today

LCOH/kg:
N/A

Current H_2 demand/yr:
Not significant

– demand focused on green bunkering, industrial heat, heavy load mobility, raw materials for industry

2030

LCOH/kg:
Renewable/Green: $5.00[169]

Domestic H_2 production/yr:
Panama has set a goal to produce 0.5 Mt of renewable/green H_2 and/or derivatives locally by 2030[170]

– the demand strategy will set a target of 5% of all bunkering fuels used by 2030 to be hydrogen or its derivatives[171]

2050

LCOH/kg:
Renewable/Green: $3.60[172]

Domestic H_2 production/yr:
Estimated production 4 Mt of renewable/green H_2 and/or derivatives[173]

Current advancement in enabling measures

Standards and certifications

To ensure clarity and standardization, Panama proposes to include renewable/green hydrogen and its derivatives into the draft law for the reform of the legal framework of the hydrocarbon sector. Sector norms need updating to include regulations on safety standards for renewable/green hydrogen and its derivatives.

Cost

The creation of a draft law tailored for renewable/green hydrogen aims to establish incentives for decarbonization and explore expansion options for investments in Panama, possibly involving international credit mechanisms. Additionally, a financing scheme for research related to the energy transition, particularly focusing on the renewable/green hydrogen supply chain, is suggested in the draft law, potentially funded by the fossil fuel sector.[174]

Panama's National Strategy for Green Hydrogen and Derivatives (ENHIVE), approved in July 2023, proposes a mitigation strategy to address the potential risks of developing the renewable/green hydrogen industry, which is led by Panama's Department of Energy (SNE), the Ministry of External Relations (MIRE) and the Maritime Authority of Panama (AMP), involving regional collaboration on green ammonia.[175] Meanwhile, ENHIVE suggests exemptions from import duties on equipment for renewable hydrogen projects[176] and proposes a financing window for renewable/green hydrogen and derivatives within Panama's Energy Transition Fund.[177]

Technology and talent

The government is establishing a competitive intelligence subcommittee to aid decision-making for implementing ENHIVE and to provide quarterly technological surveillance reports. It is also implementing an information dissemination programme to share best practices and enhance technological knowledge. ENHIVE proposes including the production of renewable/green hydrogen in the National Strategic Plan for Science, Technology and Innovation to promote Panama's competitiveness in this emerging sector.[178] The government is implementing human capital training programmes at various levels and establishing a scholarship programme for Panamanian energy sector professionals in renewable/green hydrogen to equip employees with the skills needed.

Demand

ENHIVE suggests creating a masterplan for a clean energy hub focusing on the bunkering of green ammonia and methanol for the maritime sector. The strategy proposes establishing a special state working group for this and conducting a study on the demand for green fuels such as ammonia and methanol for ships passing through the Panama Canal, with growth projections up to 2050.[179]

COUNTRY PROFILE

Panama

Infrastructure

Panama is embracing the hydrogen economy with the SGP BioEnergy biorefinery project,[180] set to produce 405,000 tonnes of renewable/green hydrogen annually. This initiative highlights Panama's dedication to renewable energy and its potential to become a key player in the hydrogen market, showcasing a significant step towards regional clean energy goals using renewable resources for hydrogen production.

Pace of development

To accelerate the development and adoption of renewable/green hydrogen, the national strategy suggests signing MoUs and commercialization agreements with countries and companies. These entities should possess strategies for renewable/green hydrogen and its derivatives, including plans for production and export of green ammonia, aligned with ENHIVE's timeline.[181] Panama's vision is to become a "diverse supermarket of energetics" for the marine sector, as part of a broader masterplan for the country's hydrogen economy.

Public policies, partnerships and funding overview

Policies

Overarching strategic vision

Policy framework

Legislation

National Strategy for Green Hydrogen and Derivatives (ENHIVE)[182]

Resolution MIPRE 2022-0002354
– adopts the bases for Phase 1 of the Green Hydrogen Roadmap[183]

Resolution MIPRE 2023-0015577
– the preliminary version of the National Strategy for Green Hydrogen and Derivatives (ENHIVE)[184]

Law 199 of 16 February 2023
– to promote and implement renewable/green hydrogen[185]

Partnerships and funding

Financial instruments

Partnerships

$240 million from Banco Centroamericano de Integración Económica (BCIE)
– to promote the energy transition[186]

Collaboration with the European Union
– to support the National Strategy for Green Hydrogen[187]

Partnership between Panama and Dominican Republic
– to support energy resources and optimize hydrogen transportation between the two countries.

Renewable/Green hydrogen international cooperation
– alliance between Italy and Latin America to support energy renewables and renewable/green hydrogen

COUNTRY PROFILE

Uruguay

Population
3.4 million

GDP
$71.2 billion (2022))

GDP per capita
$18,214

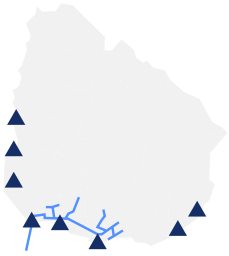
CO_2e emissions[188]
41.9 Mt (2022)

Installed renewable capacity
3.75 GW (2022)

Natural gas production
Zero (2022)

Ammonia imports (value)
$889,000 (2022)

Current infrastructure[189, 190]



Facts and figures

Source: Ministry of Industry, Energy and Mining[191]

Today

LCOH/kg:
Renewable/Green: $1.80 (for 2025)

Current H_2 demand/yr:
Not significant

– demand focused on ocean transportation, fertilizers, heavy-duty trucks, buses, tractors and other fuels

2030

LCOH/kg:
Renewable/Green: $1.30-$1.50

Domestic H_2 production/yr:
Uruguay has set a goal to achieve electrolyser capacity of 0.5-1.0 GW and 1-2 GW of renewable power capacity

– growth in demand is expected for shipping fuels (e.g. low-emission ammonia and methanol)

2050

LCOH/kg:
Renewable/Green: $1.00-$1.10

Domestic H_2 production/yr:
Uruguay's Roadmap for Green Hydrogen extends only up to 2040

Current advancement in enabling measures[192]

Standards and certifications

Uruguay's Roadmap for Green Hydrogen and Derivatives (H_2U), initiated by Presidential Resolution 294/2022, aims to coordinate and plan the development of the renewable/green hydrogen economy and its derivatives nationally. It establishes a renewable/green hydrogen inter-institutional group comprising ministries, the Office of Planning and Budgets (OPP) and state organizations, coordinated by the Ministry of Industry, Energy and Mining (MIEM). The regulation of renewable/green hydrogen production, storage and transportation falls under the jurisdiction of the Uruguayan Energy and Water Regulator (URSEA), supported by powers granted by Accountability Law No. 19996 of 2021, with safety regulations already in progress.

Cost

As part of its strategy, Uruguay is connecting continuous industrial processes to a renewable electricity grid, enhancing cost-effectiveness for producing renewable/green hydrogen. This is due to wind, solar, hydropower and biomass synergy, reducing costs by 5-10% compared to off-grid options. Electrolysis plants near renewable energy sources lower transportation costs. Coordinated infrastructure development could further decrease hydrogen costs by 4-6%. Uruguay offers stable rules, investment-grade ratings and incentives that are attractive to domestic and international investors, particularly in the renewable/green hydrogen sector.[193]

Technology and talent

Uruguay and Germany signed an agreement in March 2023 to share knowledge and technical capacities for renewable energy sources and alternative fuels.[194] Besides this, a collaboration with Chile's National Commission for Scientific and Technological Research (CONICYT) aims to develop scientific and technical capabilities, creating 30,000 skilled jobs. Uruguay efforts include raising national awareness about the potential of renewable/green hydrogen and its derivatives and forming alliances with international partners for capacity building and communication.

Demand

Renewable/green hydrogen development in Uruguay will be driven by applications that are cost-competitive against fossil fuels and other low-emission options, especially in the heavy-duty transportation and maritime sectors. Uruguay's competitive advantage lies in high-quality iron production, requiring substantial renewable/green hydrogen. Export costs align with competitors, with transportation costs minimally affecting destination costs. However, export competitiveness to Europe could be impacted by potential renewable/green hydrogen imports from North Africa.

COUNTRY PROFILE

Uruguay

Infrastructure

Uruguay is making progress in developing its hydrogen industry, with four projects at different stages of development, powered by renewable energy sources. Projects such as H24U and Paysandu aim for significant hydrogen production capacities by 2025 and 2026, respectively. Other initiatives, including H2U Offshore ANCAP and Tambor Green Hydrogen Hub, reflect Uruguay's commitment to renewable/green hydrogen integration and infrastructure development.[195] The proximity of industrial plants to renewable resources enables the use of biogenic CO_2, while robust transport infrastructure enhances local and export transportation capabilities, bolstering competitiveness.

Pace of development

Uruguay's extensive experience in renewable energy projects, backed by robust regulatory frameworks, stability in governance and sound macroeconomic conditions, renders it an appealing destination for sustainable investments.

Public policies, partnerships and funding overview[196]

Policies

Overarching strategic vision

Policy framework

Legislation

Uruguay's Roadmap for Green Hydrogen and Derivatives (H2U)[197]

Presidential Resolution 294 of 2022 entrusting MIEM with implementing the H2U Program[198]

Article 150 of the Accountability Law No. 19996 of 2021
– to regulate the production, storage and transportation of renewable/green hydrogen and its derivatives[199]

Decree No. 349 of 2005 and amendments[200]

Article 47 of the Uruguayan Constitution[201]

Law No. 18308 of 2008[202]

Decree 242 of 2023[203]

Partnerships and funding

Financial instruments

Partnerships

ANCAP-HIF Global
– a feasibility study by Uruguay's state oil company (ANCAP) and private sector partner for a new $4 billion renewable/green hydrogen project[204]

Renewable/green hydrogen and e-fuels auction
– the government will provide $10 million in grants for the construction of the $43.5 million H24U renewable/green hydrogen facility by Uruguayan companies Saceem and CIR.[205]

Port of Rotterdam
– a pact with Uruguay to cooperate on renewable/green hydrogen and its derivatives[206]

Germany joint declaration of intent
– creation of working groups to promote exchange and actions on topics such as renewable/green hydrogen, energy efficiency, electric mobility and battery storage[207]

Enertrag
– plans by German renewables company Enertrag to develop the Tambor Green Hydrogen Hub in the department of Tacuarembo[208]

Contributors

World Economic Forum

Anne Therese Andersen
Programme Analyst, Centre for Energy and Materials

Marisol Argueta de Barillas
Head of the Regional Agenda, Latin America; Member of the Executive Committee

Roberto Bocca
Head of the Centre for Energy and Materials; Member of the Executive Committee

Diego Bustamente
Deputy Head, Latin America

Marina Colombo
Manager, Transforming Industrial Ecosystems

Emilie Kaern
Lead, Transitioning Industrial Clusters

Charles Pacini
Manager, Transforming Industrial Ecosystems

Natalia Suescun Pozas
Partner Lead, Latin America

Jörgen Sandström
Head, Transforming Industrial Ecosystems

Irene Varoli
Lead, Transitioning Industrial Clusters

Accenture

Muqsit Ashraf
Group Chief Executive, Strategy

Maria Contreras
Management Consulting Analyst

Benjamin Duwald
Strategy Manager

Octavia Maes-Kopff
Strategy Analyst

Andrea Mier
Management Consultant

Orla Nimmo
Management Consultant

Catherine O'Brien
Managing Director, Energy Transition Services, EMEA

Alexander Oei
Strategy Manager

Guillermo Quiñones
Managing Director, Energy Transition Services, Growth Markets

Miguel Torreira
Global Utilities Strategy Lead

Acknowledgements

Production

Laurence Denmark
Creative Director, Studio Miko

Oliver Turner
Designer, Studio Miko

Jonathan Walter
Editor

Endnotes

1. World Meteorological Organization (WMO), Climate change indicators reached record levels in 2023: WMO, March 2024, https://wmo.int/news/media-centre/climate-change-indicators-reached-record-levels-2023-wmo.
2. International Renewable Energy Agency (IRENA), World Energy Transitions Outlook 2022, March 2023, https://www.irena.org/Digital-Report/World-Energy-Transitions-Outlook-2022.
3. United Nations Industrial Development Organization (UNIDO), Global Programme for Hydrogen in Industry, Coordination, June 2024, https://hydrogen.unido.org/coordination.
4. United Nations Industrial Development Organization (UNIDO), Global Programme for Hydrogen in Industry, Coordination, June 2024, https://hydrogen.unido.org/coordination.
5. Green Hydrogen Organisation, The GH2 Country Portal – Chile, https://gh2.org/countries/chile.
6. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
7. World Economic Forum, First Movers Coalition: Status Report, July 2024, Fig. 1, p.10, https://www3.weforum.org/docs/WEF_First_Movers_Coalition_Status_Report_2024.pdf.
8. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
9. International Energy Agency (IEA), Renewable electricity capacity growth by country or region, main case, 2005-2028, January 2024, https://www.iea.org/data-and-statistics/charts/renewable-electricity-capacity-growth-by-country-or-region-main-case-2005-2028.
10. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
11. International Energy Agency (IEA), Hydrogen in Latin America: From near-term opportunities to large-scale deployment, August 2021, https://www.iea.org/reports/hydrogen-in-latin-america.
12. International Energy Agency (IEA), Global Hydrogen Review 2022, September 2022, https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf.
13. International Energy Agency (IEA), Global Hydrogen Review 2023, September 2023, Fig. 3.13, p.85, https://www.iea.org/reports/global-hydrogen-review-2023.
14. Projections sourced from:
    - International Energy Agency (IEA), Global Hydrogen Review 2022, September 2022, https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf.
    - Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
15. Hydrogen Council, Global Hydrogen Flows: Hydrogen trade as a key enabler for efficient decarbonization, October 2022, https://hydrogencouncil.com/wp-content/uploads/2022/10/Global-Hydrogen-Flows.pdf.
16. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
17. International Energy Agency (IEA), Global Hydrogen Review 2022, September 2022, https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf.
18. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
19. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
20. World Bank, Chile to Accelerate its Green Hydrogen Industry with World Bank Support, 29 June 2023, https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support.
21. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
22. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, p.7, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
23. Ministry of Mines and Energy Colombia, Colombia's hydrogen roadmap, October 2021, p.19, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
24. Government of Uruguay: Ministry of Industry, Energy and Mining, Green Hydrogen Roadmap, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.

25. International Energy Agency (IEA), Global Hydrogen Review 2022, September 2022, https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf.
26. International Energy Agency (IEA), Global Hydrogen Review 2023, September 2023, https://www.iea.org/reports/global-hydrogen-review-2023.
27. International Renewable Energy Agency (IRENA), Making the breakthrough: Green hydrogen policies and technology costs, 2021, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_Hydrogen_breakthrough_2021.pdf.
28. International Renewable Energy Agency (IRENA), Renewable Power Generation Costs in 2022, August 2023, https://www.irena.org/Publications/2023/Aug/Renewable-power-generation-costs-in-2022.
29. Nabil, B. et al, Process Parametrs Affecting the Hydrogen Production by Water Electrolysis and Electrolyser Characteristic, International Journal of Chemical and Process Engineering Research, 2015, https://archive.conscientiabeam.com/index.php/65/article/view/1801.
30. Institute of the Americas, Latin America Energy Transition Workforce Readiness Assessment, 2022, https://iamericas.org/wp-content/uploads/dlm_uploads/2022/06/IOA-ENERGY-TRANSITION-REPORT-2.pdf.
31. International Energy Agency (IEA), Global Hydrogen Review 2022, September 2022, https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf.
32. International Renewable Energy Agency (IRENA), Geopolitics of the Energy Transformation: The Hydrogen Factor, 2022, https://www.irena.org/Digital-Report/Geopolitics-of-the-Energy-Transformation.
33. International Energy Agency (IEA), Change in hydrogen demand by sector in Latin America in the Accelerated case, 2019-2030, August 2021, https://www.iea.org/data-and-statistics/charts/change-in-hydrogen-demand-by-sector-in-latin-america-in-the-accelerated-case-2019-2030.
34. Development Bank of Latin America and the Caribbean Bank (CAF), The development of the green hydrogen industry in Latin America, 28 July 2023, https://www.caf.com/es/conocimiento/visiones/2023/07/el-desarrollo-de-la-industria-del-hidrogeno-verde-en-america-latina/.
35. International Energy Agency (IEA), Global Hydrogen Review 2023, September 2023, https://www.iea.org/reports/global-hydrogen-review-2023.
36. The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Hydrogen RD&D Collaboration Opportunities: Global Report, August 2022, https://www.mission-innovation.net/wp-content/uploads/2022/09/H2RDD-Global-FINAL.pdf.
37. World Energy Council, Working Paper: Regional Insights into Low-Carbon Hydrogen Scale Up, April 2022, https://www.worldenergy.org/publications/entry/regional-insights-low-carbon-hydrogen-scale-up-world-energy-council.
38. United Nations Industrial Development Organization (UNIDO), Global Programme for Hydrogen in Industry, Coordination, June 2024, https://hydrogen.unido.org/coordination.
39. United Nations Industrial Development Organization (UNIDO), Global Programme for Hydrogen in Industry, Coordination, June 2024, https://hydrogen.unido.org/coordination.
40. International Renewable Energy Agency (IRENA), Renewable capacity statistics 2023, March 2023, https://www.irena.org/Publications/2023/Mar/Renewable-capacity-statistics-2023.
41. Global Energy Monitor, Latin American Energy Portal, Oil and gas projects of Latin America and the Caribbean, 2023, https://portalenergetico.org/oil-gas-map/.
42. Argentina Presidency, Secretariat for Strategic Affairs, National Strategy for the Development of the Hydrogen Economy, 2023, https://www.argentina.gob.ar/sites/default/files/2023/07/enh2_-_english.pdf.
43. Latin American Energy Portal, Oil and gas projects of Latin America and the Caribbean, 2023, https://portalenergetico.org/oil-gas-map/.
44. Argentina Presidency, Secretariat for Strategic Affairs, National Strategy for the Development of the Hydrogen Economy, 2023, https://www.argentina.gob.ar/sites/default/files/2023/07/enh2_-_english.pdf.
45. Argentina Presidency, Secretariat for Strategic Affairs, National Strategy for the Development of the Hydrogen Economy, 2023, https://www.argentina.gob.ar/sites/default/files/2023/07/enh2_-_english.pdf.
46. Government of Argentina, National Congress of Argentina, Law 27191 of 2015: National Promotion System for the use of Renewable Energy Sources for the Production of Electrical Energy, Modification, 15 October 2015, https://www.argentina.gob.ar/normativa/nacional/253626/texto.
47. World Bank, Financial Solutions Brief: Argentina Renewable Energy Auctions, 2018, https://thedocs.worldbank.org/en/doc/263381518200588533-0100022018/original/BriefsGuaranteesArgentinaAuctions.pdf.
48. World Bank, Argentina: Boosting private investments in renewable energy, 1 March 2017, https://www.bancomundial.org/es/news/press-release/2017/03/01/promoting-private-investment-renewable-energy-argentina.
49. Inter-American Development Bank, Argentina promotes sustainable and resilient growth with IDB support, June 2023, https://www.iadb.org/es/noticias/argentina-promueve-el-crecimiento-sostenible-y-resiliente-con-apoyo-del-bid.
50. National Council for Scientific and Technical Research (CONICET), Y-TEC launches H2ar, a consortium for the development of the hydrogen economy, 16 July 2020, https://www.conicet.gov.ar/y-tec-lanza-h2ar-un-consorcio-para-el-desarrollo-de-la-economia-del-hidrogeno/.
51. Government of Argentina, The President signed a memorandum of energy cooperation with the European Union, 17 July 2023, https://www.casarosada.gob.ar/slider-principal/50053-el-presidente-firmo-un-memorandum-de-cooperacion-energetica-con-la-union-europea.
52. Government of Argentina, Call for projects on energy transition/green energy between Argentina and Germany, 2023, https://www.argentina.gob.ar/ciencia/financiamiento/energia-verde-argentina-alemania-2023.

53. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.
54. National Agency of Petroleum, Natural Gas and Biofuels (ANP), The O&G Sector in Brazil, May 2023, https://www.gov.br/anp/pt-br/centrais-de-conteudo/apresentacoes-palestras/2023/arquivos/2023-06-01-rodolfo-saboia-cippe.pdf.
55. Uni International, The most important Brazilian ports, https://www.uniinternational.com/brazil-ports.html.
56. Neves, L., Green Hydrogen in Brazil at a levelized cost between $2.87 and $3.56/kg, PV Magazine, 1 September 2023, https://www.pv-magazine-latam.com/2023/09/01/hidrogeno-verde-en-brasil-con-un-coste-nivelado-entre-287-y-356-dolares-kg/.
57. International Energy Agency (IEA), Hydrogen in Latin America: From near-term opportunities to large-scale deployment, August 2021, https://www.iea.org/reports/hydrogen-in-latin-america.
58. Boese Cortés, I. and Soto, I., Renewable Hydrogen in Latin America and the Caribbean, Opportunities, Challenges and Pathways, LAC Green Hydrogen Action, August 2023, https://alianzaporelhidrogeno.cr/wp-content/uploads/2023/08/2023-Renewable-Hydrogen-in-Latin-America-and-The-Caribean_Opportunities-Challenges-and-Pathways.pdf.
59. McKinsey & Company, The green hidden gem – Brazil's opportunity to become a sustainability powerhouse, 4 November 2022, https://www.mckinsey.com/br/en/our-insights/all-insights/the-green-hidden-gem-brazils-opportunity-to-become-a-sustainability-powerhouse.
60. McKinsey & Company, The green hidden gem – Brazil's opportunity to become a sustainability powerhouse, 4 November 2022, https://www.mckinsey.com/br/en/our-insights/all-insights/the-green-hidden-gem-brazils-opportunity-to-become-a-sustainability-powerhouse.
61. Boese Cortés, I. and Soto, I., Renewable Hydrogen in Latin America and the Caribbean, Opportunities, Challenges and Pathways, LAC Green Hydrogen Action, August 2023, https://alianzaporelhidrogeno.cr/wp-content/uploads/2023/08/2023-Renewable-Hydrogen-in-Latin-America-and-The-Caribean_Opportunities-Challenges-and-Pathways.pdf.
62. Brazilian Center for International Relations (CEBRI), Energy Transition Program, Carbon Neutrality 2050: Scenarios for an Efficient Transition in Brazil, February 2023, https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-726/PTE_RelatorioFinal_EN_5JUN.pdf.
63. Ministry of Mines and Energy, Government of Brazil, National Hydrogen Program (PNH2), July 2021, https://www.gov.br/mme/pt-br/assuntos/noticias/mme-apresenta-ao-cnpe-proposta-de-diretrizes-para-o-programa-nacional-do-hidrogenio-pnh2/HidrognioRelatriodiretrizes.pdf.
64. Argus Media, Brazil taps into green hydrogen certification, August 2022, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2365580-brazil-taps-into-green-hydrogen-certification.
65. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
66. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
67. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
68. Tozzini Freire Advogados, Green hydrogen projects in Brazil: All you need to know from a legal perspective, 15 August 2023, https://tozzinifreire.com.br/en/boletins/green-hydrogen-projects-in-brazil-all-you-need-to-know-from-a-legal-perspective.
69. Rödl & Partner, Brazil – The imminent boom of green hydrogen, 10 July 2023, https://www.roedl.com/insights/renewable-energy/2023/june/brazil-boom-of-green-hydrogen.
70. Tozzini Freire Advogados, Green hydrogen projects in Brazil: All you need to know from a legal perspective, 15 August 2023, https://tozzinifreire.com.br/en/boletins/green-hydrogen-projects-in-brazil-all-you-need-to-know-from-a-legal-perspective.
71. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
72. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
73. Energy Research Company of Brazil, National Energy Plan 2050, July 2020, https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/Plano-Nacional-de-Energia-2050.
74. Ministry of Mines and Energy, Government of Brazil, National Hydrogen Program (PNH2), July 2021, https://www.gov.br/mme/pt-br/assuntos/noticias/mme-apresenta-ao-cnpe-proposta-de-diretrizes-para-o-programa-nacional-do-hidrogenio-pnh2/HidrognioRelatriodiretrizes.pdf.
75. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
76. Neves, L., Brazilian Pact for Renewable Hydrogen Launched, PV Magazine, 8 May 2023, https://www.pv-magazine-latam.com/2023/05/08/lanzan-el-pacto-brasileno-por-el-hidrogeno-renovable/.
77. Electric Energy Trading Chamber of Brazil (CCEE), CCEE launches first Brazilian certification of renewable hydrogen, 8 December 2022, https://www.ccee.org.br/pt/web/guest/-/ccee-lanca-primeira-certificacao-brasileira-de-hidrogenio-renovavel.
78. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
79. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.

80. Rödl & Partner, Brazil – The imminent boom of green hydrogen, 10 July 2023, https://www.roedl.com/insights/renewable-energy/2023/june/brazil-boom-of-green-hydrogen.
81. Silva, M., Scaling up green hydrogen for inclusive growth, better jobs, and lower emissions, World Bank Blogs, 31 October 2023, https://blogs.worldbank.org/en/energy/scaling-green-hydrogen-inclusive-growth-better-jobs-and-lower-emissions.
82. Vale, Vale and Petrobras sign Protocol of Intent to accelerate the development of low-carbon solutions, 28 September 2023, https://vale.com/w/vale-and-petrobras-sign-protocol-of-intent-to-accelerate-the-development-of-low-carbon-solutions.
83. Renewables Now, Green Energy Park plans 5-GW green ammonia project in Brazil, 12 October 2023, https://renewablesnow.com/news/green-energy-park-plans-5-gw-green-ammonia-project-in-brazil-836616/.
84. Green Hydrogen Organisation, GH2 Country Portal – Brazil, https://gh2.org/countries/brazil.
85. ENGIE, ENGIE joins forces with the Brazilian H2 Association, to accelerate the adoption of green H2 technologies in Brazil, 4 August 2021, https://www.engie.com.br/en/imprensa/press-releases/engie-joins-forces-with-the-brazilian-h2-association-to-accelerate-the-adoption-of-green-h2-technologies-in-brazil/.
86. Port of Rotterdam, Green hydrogen corridors transforming the future, 18 January 2022, https://www.portofrotterdam.com/en/news-and-press-releases/green-hydrogen-corridors-transforming-the-future.
87. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.
88. Latin American Energy Portal, Oil and gas projects of Latin America and the Caribbean, 2023, https://portalenergetico.org/oil-gas-map/.
89. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
90. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
91. Green Hydrogen Organisation, GH2 Country Portal – Chile, https://gh2.org/countries/chile.
92. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
93. World Bank, Chile to Accelerate its Green Hydrogen Industry with World Bank Support, 29 June 2023, https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support.
94. Green Hydrogen Organisation, GH2 Country Portal – Chile, https://gh2.org/countries/chile.
95. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
96. Chile Foundation, A Strategic Opportunity for Chile: Green Hydrogen, https://fch.cl/en/initiative/green-hydrogen/.
97. Fuel Cells Works, EU-Chile Trade Agreement Focusing on Hydrogen and Renewable Electricity Awaits Council Authorization, 5 July 2023, https://fuelcellsworks.com/news/eu-chile-trade-agreement-focusing-on-hydrogen-and-renewable-electricity-awaits-council-authorization/.
98. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
99. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
100. VINCI Concessions, Santiago airport launches plan to become the first in Latin America to operate with green hydrogen, 7 June 2022, https://en.newsroom.vinci-concessions.com/news/santiago-airport-launches-plan-to-become-the-first-in-latin-america-to-operate-with-green-hydrogen-03dd-55ff8.html.
101. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
102. Green Hydrogen Organisation, The GH2 Country Portal – Chile, https://gh2.org/countries/chile.
103. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
104. Ministry of Energy, Government of Chile, National Green Hydrogen Strategy, November 2020, https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf.
105. Ministry of Energy, Government of Chile, Green Hydrogen Action Plan 2023-2030, April 2024, https://energia.gob.cl/sites/default/files/documentos/green-hydrogen_action-plan.pdf.
106. Ministry of Transport and Telecommunications, Government of Chile, Public Consultation SAF 2050 Roadmap, January 2024, http://www.mtt.gov.cl/consulta-publica-hoja-de-ruta-saf-2024.
107. Green Hydrogen Organisation, The GH2 Country Portal – Chile, https://gh2.org/countries/chile.
108. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
109. World Bank, Chile to Accelerate its Green Hydrogen Industry with World Bank Support, 29 June 2023, https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support.

110. Green Hydrogen Organisation, The GH2 Country Portal – Chile, https://gh2.org/countries/chile.
111. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
112. Hydrogen Central, Chile – ENAP Signs an Agreement with Six Energy Companies to Generate The Largest Green Hydrogen Infrastructure Development In The Country, 23 August 2023, https://hydrogen-central.com/chile-enap-signs-agreement-six-energy-companies-generate-largest-green-hydrogen-infrastructure-development-in-the-country/.
113. Federal Ministry for Economic Affairs and Climate Action of Germany (BMWK), Green hydrogen from Chile using technology 'Made in Germany', November 2020, https://www.bmwk-energiewende.de/EWD/Redaktion/EN/Newsletter/2020/11/Meldung/news2.html.
114. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.
115. Promigas, Report of Natural Gas Sector 2021: Gas pipeline network, https://www.promigas.com/informeSector2020/Paginas/Transporte-gasCol.aspx.
116. The Logistics World, Colombia: main maritime ports, April 2022, https://thelogisticsworld.com/comercio-internacional/principales-puertos-maritimos-de-colombia/.
117. German Development Agency (GIZ), Identification of Green H2 hubs in Colombia, 2023, https://h2lac.org/wp-content/uploads/2024/01/H2_Hubs_Executive_Summary.pdf.
118. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
119. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
120. HINICIO Colombia, Recommendations for Hydrogen Origin Certification, April 2022, https://www.minenergia.gov.co/documents/8596/Recomendaciones_Certificacion_de_origen_hidrogeno.pdf.
121. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
122. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
123. Ministry of Environment and Sustainable Development Colombia, Law 1964 of 2019 to promote use of electric vehicles, July 2019, https://www.minambiente.gov.co/documento-normativa/ley-1964-de-2019/.
124. Ministry of Environment and Sustainable Development Colombia, Law 1931 of 2018 to establish guidelines for climate change management, July 2018, https://www.minambiente.gov.co/documento-normativa/ley-1931-de-2018/.
125. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
126. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
127. Ministry of Trade, Industry and Tourism, Government of Colombia, Law 2069 of 2020 to promote entrepreneurship, December 2020, https://www.mincit.gov.co/normatividad/leyes/2020/ley-2069-del-31-de-diciembre-de-2020-por-medio-del.
128. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
129. Ministry of Mines and Energy, Government of Colombia, Colombia's hydrogen roadmap, October 2021, https://www.minenergia.gov.co/static/ruta-hidrogeno/src/document/Colombia%20Hydrogen%20Roadmap_2810.pdf.
130. Ministry of Trade, Industry and Tourism Colombia, Law 2069 of 2020 to promote entrepreneurship, December 2020, https://www.mincit.gov.co/normatividad/leyes/2020/ley-2069-del-31-de-diciembre-de-2020-por-medio-del.
131. Mining and Energy Planning Unit, Government of Colombia, Law 1715 of 2014 to integrate Renewable-Non-Conventional Energy Sources, May 2014, http://www.upme.gov.co/Normatividad/Nacional/2014/LEY_1715_2014.pdf.
132. Government of Colombia, Law 2099 of 2021 for the energy transition, dynamization of energy market and economic reactivation, July 2021, https://www.funcionpublica.gov.co/eva/gestornormativo/norma_pdf.php?i=166326.
133. Ministry of Trade, Industry and Tourism, Government of Colombia, Law 2069 of 2020 to promote entrepreneurship, December 2020, https://www.mincit.gov.co/normatividad/leyes/2020/ley-2069-del-31-de-diciembre-de-2020-por-medio-del.
134. Government of Colombia, Decree 2235 of 2023 for the development of white hydrogen projects, December 2023, https://www.funcionpublica.gov.co/eva/gestornormativo/norma_pdf.php?i=227190.
135. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
136. FENOGE, Government of Colombia, We are the Non-Conventional Energy and Efficient Energy Management Fund – FENOGE, https://fenoge.gov.co/quienes-somos/.
137. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
138. Universidad Externado de Colombia: Department of Environmental Law, Financing of green hydrogen projects in Colombia, May 2023, https://medioambiente.uexternado.edu.co/financiacion-de-proyectos-de-hidrogeno-verde-en-colombia/.

139. World Bank, World Bank and Colombia Reaffirm Commitment to Climate Action, 1 April 2024, https://www.bancomundial.org/es/news/press-release/2024/04/11/el-banco-mundial-y-colombia-reafirman-su-compromiso-con-la-accion-climatica.
140. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
141. Medellín Public Companies (EPM), Memorandum of Understanding between EPM and JBIC for the promotion of renewable energy and public service projects, 11 April 2024, https://www.epm.com.co/institucional/sala-de-prensa/noticias-y-novedades/memorando-de-entendimiento-entre-jbic-y-epm.html.
142. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
143. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
144. PROCOLOMBIA, Colombia, the only Latin American country at the South Korean hydrogen summit, 14 September 2023, https://prensa.procolombia.co/colombia-unico-pais-latinoamericano-en-cumbre-de-hidrogeno-de-corea-del-sur.
145. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.
146. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
147. US Energy Information Administration (EIA), U.S. natural gas exports to Mexico set to rise with completion of the Wahalajara system, July 2020, https://www.eia.gov/todayinenergy/detail.php?id=44278.
148. Hydrogen Association of Mexico, Green hydrogen: the energy vector to decarbonize the economy of Mexico, 25 May 2022, https://h2mex.org/wp-content/uploads/HidrogenoVerde_Estudio_H2mex.pdf.
149. Hydrogen Association of Mexico, Green hydrogen: the energy vector to decarbonize the economy of Mexico, 25 May 2022, https://h2mex.org/wp-content/uploads/HidrogenoVerde_Estudio_H2mex.pdf.
150. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
151. Hydrogen Association of Mexico, Green hydrogen: the energy vector to decarbonize the economy of Mexico, 25 May 2022, https://h2mex.org/wp-content/uploads/HidrogenoVerde_Estudio_H2mex.pdf.
152. CMS, Hydrogen law, regulations & strategy in Mexico, 24 November 2021, https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/mexico.
153. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
154. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
155. Hydrogen Association of Mexico, Green hydrogen: the energy vector to decarbonize the economy of Mexico, 25 May 2022, https://h2mex.org/wp-content/uploads/HidrogenoVerde_Estudio_H2mex.pdf.
156. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
157. Secretariat of Energy (SENER), Government of Mexico, SENER publishes Transition Strategy to Promote the Use of Cleaner Technologies and Fuels, 7 February 2020, https://www.gob.mx/cenace/es/articulos/sener-publica-estrategia-de-transicion-para-promover-el-uso-de-tecnologias-y-combustibles-mas-limpios?idiom=es.
158. Institute of Legal Research, Government of Mexico, Political Constitution of the United Mexican States, January 2016, https://archivos.juridicas.unam.mx/www/legislacion/federal/leyes/consting.pdf.
159. National Commission for the Efficient Use of Energy, Government of Mexico, Regulatory framework for energy transition, 24 December 2015, https://www.gob.mx/conuee/acciones-y-programas/marco-normativo-de-la-transicion-energetica-138565.
160. Government of Mexico, Law for the Electric Industry, 11 August 2014, https://www.diputados.gob.mx/LeyesBiblio/pdf/LIElec.pdf.
161. Government of Mexico, General Law for Climate Change, 6 June 2012, https://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC.pdf.
162. Atchison, J., Hy2gen announces new ammonia project in Mexico, Ammonia Energy Association, 24 July 2023, https://ammoniaenergy.org/articles/hy2gen-announces-new-ammonia-project-in-mexico/.
163. The Mexican-German Energy Partnership, https://www.energypartnership.mx/fileadmin/user_upload/mexico/media_elements/reports/Hydrogen_EP_volume_I.pdf.
164. Forbes Mexico, Companies forge alliance to produce green hydrogen in Mexico, 29 March 2023, https://www.forbes.com.mx/empresas-forjan-alianza-para-producir-hidrogeno-verde-en-mexico/.
165. Department of Energy, Government of the United States of America, U.S., Mexico Energy Officials Convene at Clean Hydrogen Seminar in Mexico City, 21 November 2023, https://www.energy.gov/eere/fuelcells/articles/us-mexico-energy-officials-convene-clean-hydrogen-seminar-mexico-city.
166. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.

167. Latin American Energy Portal, Oil and gas projects of Latin America and the Caribbean, 2023, https://portalenergetico.org/oil-gas-map/.
168. Panama Maritime Authority, Map of Ports and Industries maritime and auxiliary, https://www.amp.gob.pa/servicios/puertos-e-industrias-maritimas-auxiliares/infraestructura/puertos-estatales-2/.
169. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
170. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
171. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
172. Inter-American Development Bank, Unlocking Green and Just Hydrogen in Latin America and the Caribbean, June 2023, https://publications.iadb.org/en/publications/english/viewer/Unlocking-Green-and-Just-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.
173. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
174. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
175. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
176. Argus Media, Panama plans international hydrogen organisation, 20 April 2023, https://www.argusmedia.com/en/news-and-insights/latest-market-news/2441106-panama-plans-international-hydrogen-organisation.
177. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
178. National Energy Secretariat, Government of Panama, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
179. Government of Panama: National Energy Secretariat, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
180. SGP BioEnergy, SGP BioEnergy Adds Green Hydrogen to Planned World's Largest Advanced Biofuel Production Facility, 4 March 2024, https://sgpbioenergy.com/2024/03/04/sgp-bioenergy-adds-green-hydrogen-to-planned-worlds-largest-advanced-biofuel-production-facility/.
181. Government of Panama: National Energy Secretariat, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
182. Government of Panama: National Energy Secretariat, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
183. Alemán, Cordero, Galindo & Lee, Panama approves its National Green Hydrogen Strategy, 21 November 2023, https://focusalcogal.com/en/panama-approves-its-national-green-hydrogen-strategy/.
184. Government of Panama: National Energy Secretariat, National Strategy for green hydrogen and its derivatives, April 2023, https://noticiasdepanama.com/wp-content/uploads/2023/05/Estrategia-Nacional-de-Hidrogeno-verde-y-derivados-de-Panama%CC%81.pdf.
185. National Assembly, Government of Panama, Project of Law 199 of 2023 to promote the implementation of green hydrogen, February 2023, https://espaciocivico.org/sites/default/files/proyectos-ley/2023_A_199.pdf.
186. Central American Bank for Economic Integration (CABEI), CABEI approves US$240 million to the Republic of Panama for energy transition in the country, 15 March 2024, https://www.bcie.org/en/news-and-media/events/event/bcie-aprueba-a-la-republica-de-panama-us240-millones-para-la-transicion-energetica-del-pais.
187. Ministry of Environment, Government of Panama, The European Union strengthens its collaboration with Panama in promoting the development of the green hydrogen market, 24 November 2023, https://www.miambiente.gob.pa/la-union-europea-refuerza-su-colaboracion-con-panama-en-la-promocion-del-desarrollo-del-mercado-de-hidrogeno-verde/.
188. European Commission, EDGAR – Emissions Database for Global Atmospheric Research, GHG emissions of all world countries, 2023 report, September 2023, https://edgar.jrc.ec.europa.eu/report_2023.
189. Latin American Energy Portal, Oil and gas projects of Latin America and the Caribbean, 2023, https://portalenergetico.org/oil-gas-map/.
190. National Logistics Institute (INALOG), Port Infrastructure of Uruguay, http://www.inalog.org.uy/es/infraestructura-puertos-libres/#:~:text=En%20Uruguay%20existen%208%20puertos,%2C%20M'Bopicu%C3%A1%20y%20Paysand%C3%BA.

191. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Uruguay's Roadmap for Green Hydrogen and Derivatives, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.
192. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Uruguay's Roadmap for Green Hydrogen and Derivatives, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.
193. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
194. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Uruguay's Roadmap for Green Hydrogen and Derivatives, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.
195. World Hydrogen Latin America, Hydrogen Market Updates from across Latin America, October 2023, info.greenpowerglobal.com/whlatam-report/?_gl=1*f9fcok*_ga*MTY5Njg3NzIwNC4xNzAxMjc2MjQ1*_ga_008GQ811NF*MTcwMTI3NjI0Ni4xLjAuMTcwMTI3NjI0Ni4wLjAuMA.
196. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Uruguay's Roadmap for Green Hydrogen and Derivatives, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.
197. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Uruguay's Roadmap for Green Hydrogen and Derivatives, April 2021, https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay.
198. Official Information Centre, Government of Uruguay, Resolution 294/022: Implementation and Administration of the "H2U Program", in Charge of the Ministry of Industry, Energy and Mining, Aimed at Promoting the Development of Green Hydrogen in Uruguay, 13 January 2023, https://www.impo.com.uy/bases/resoluciones/294-2022.
199. Ministry of Industry, Energy and Mining, Government of Uruguay, H2U Program, Presidential Resolution 294/022, 29 December 2022, https://www.gub.uy/ministerio-industria-energia-mineria/politicas-y-gestion/programa-h2u.
200. Official Information Centre, Government of Uruguay, Decree 349/005, Regulations on Environmental Impact Assessment and Environmental Authorizations, 3 October 2005, https://www.impo.com.uy/bases/decretos/349-2005.
201. Parliament of Uruguay, Constitution of the Republic, Article 47 for the protection of the environment, 1997, https://parlamento.gub.uy/documentosyleyes/constitucion.
202. Official Information Centre, Government of Uruguay, Law 18308 of 2008, Land Use Planning and Sustainable Development Law, 30 June 2008, https://www.impo.com.uy/bases/leyes/18308-2008.
203. Official Information Centre, Government of Uruguay, Decree 242/023, Modification of the Regulations of the Wholesale Electricity Market, 14 August 2023, https://www.impo.com.uy/bases/decretos/242-2023.
204. H2LAC Platform for the Development of Green Hydrogen in Latin America and the Caribbean, ANCAP announces that HIF Global will carry out an e-fuels project in Uruguay with an investment of US$ 4 billion, 14 June 2023, https://h2lac.org/noticias/ancap-anuncia-que-hif-global-realizara-proyecto-de-e-fuels-en-uruguay-con-una-inversion-de-us-4-000-millones/.
205. Energía Estratégica, Uruguay advances in the first Green Hydrogen Project developed by the companies CIR and SACEEM, 8 June 2023, https://www.energiaestrategica.com/uruguay-avanza-en-el-primer-proyecto-de-hidrogeno-verde-desarrollado-por-las-empresas-cir-y-saceem/.
206. Renewables Now, Uruguay, Port of Rotterdam ink green hydrogen MoU, 12 May 2023, https://renewablesnow.com/news/uruguay-port-of-rotterdam-ink-green-hydrogen-mou-822885/.
207. Matalucci, S., The Hydrogen Stream: Germany expands global hydrogen alliances, PV Magazine, 26 September 2023, https://www.pv-magazine.com/2023/09/26/the-hydrogen-stream-germany-expands-global-hydrogen-alliances/.
208. Djunisic, S., Enertrag unveils wind and solar-backed green H2 project in Uruguay, Renewables Now, 10 May 2022, https://renewablesnow.com/news/enertrag-unveils-wind-and-solar-backed-green-h2-project-in-uruguay-784028/.

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

The World Economic Forum, committed to improving the state of the world, is the International Organization for Public-Private Cooperation.

The Forum engages the foremost political, business and other leaders of society to shape global, regional and industry agendas.

World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org