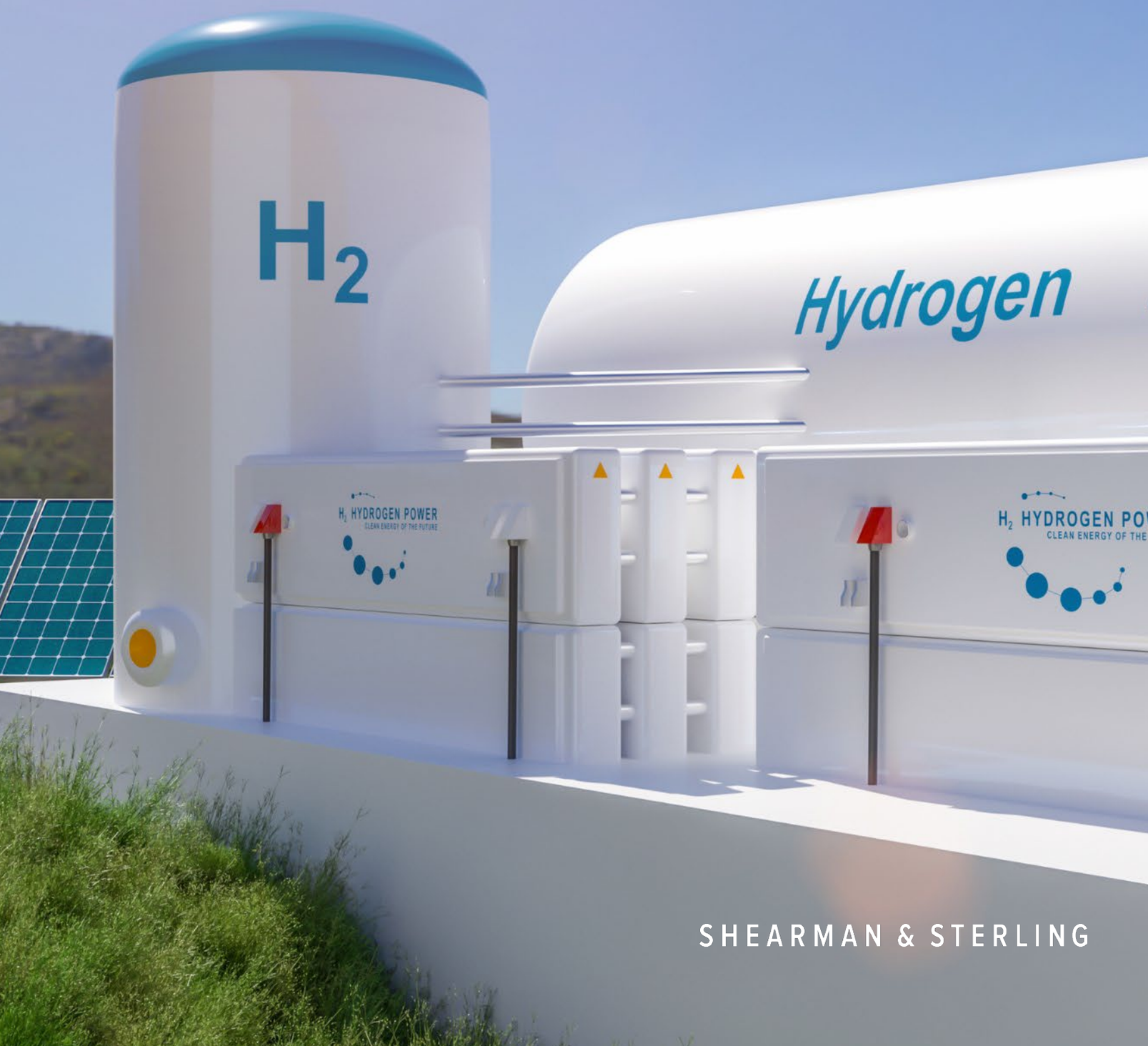
LatAm H2: The Growing Importance of Low-Carbon Hydrogen in Latin America

2022



SHEARMAN & STERLING

THE COMING HYDROGEN RENAISSANCE

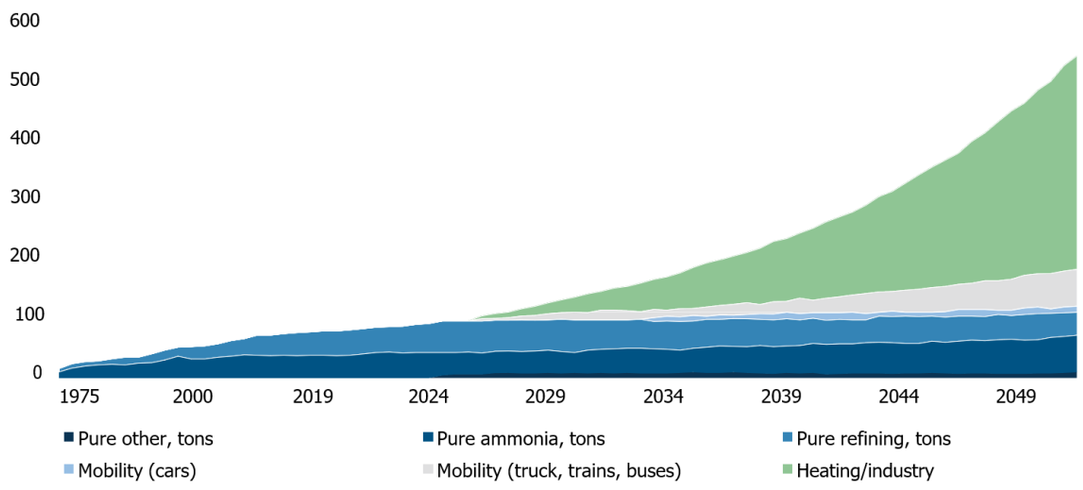
As the world increasingly commits to climate action, and governments and companies pledge net-zero emissions by or before 2050, it is clear that the demand for hydrogen – an essential element of a low-carbon economy – is going to dramatically increase in industrial and consumer sectors across the globe.

As both an energy storage mechanism and a fuel source, hydrogen has long had its supporters, but for decades they have been on the margins of energy system futurism. A number of factors have held off the global market from maturing, including the cost differential of hydrogen compared to fossil fuels (on an equivalent calorific value basis), the need for a significant infrastructure build-out, and the repeated cycles of hydrogen hype throughout the 20th century that failed to gain traction. Furthermore, the development of renewable hydrogen (e.g., blue, green, aqua, red) is reliant on the scaling of adjacent renewable technologies, such as wind, solar and nuclear power.

Globally, a number of advances over the past decade indicates a coming hydrogen renaissance with significant staying power, supported by strong demand. These advances are particularly evidenced by a reduction in renewable power production costs, an increasing pressure to decarbonize economies, and a global diversification of energy supplies due to geopolitical supply/security concerns. Demand is expected to grow exponentially in the coming years, especially for hard-to-abate industrial sectors. Heavy polluting, fossil-fuel reliant industries such as mining and production of steel, cement, aluminum, fertilizers and petrochemicals, account for 30% of total global carbon dioxide emissions and 34% of total global methane emissions, according to the latest data from McKinsey & Co. The steel sector alone accounts for 7-9% of all fossil fuel emissions. It is in these sectors that hydrogen is gaining the most momentum.

Hydrogen also has a considerable role to play in energy storage and in the transportation sector, in particular with heavy duty vehicles. In the near future, hydrogen will complement lithium-ion batteries. Batteries will be used for short-term needs and where the mobility and compact form factors of the technology are of paramount consideration. Meanwhile, hydrogen will be used for long-duration energy storage, whether for the next week or the next season. Some hydrogen use cases will likely transcend the time gaps, particularly in the long-haul transportation sector. Pushing the envelope are firms like the European aircraft manufacturer Airbus, which intends to have hydrogen-fueled aircraft in service by 2035.

HYDROGEN DEMAND IS EXPECTED TO GROW RAPIDLY (Million tons (Mt)/year)



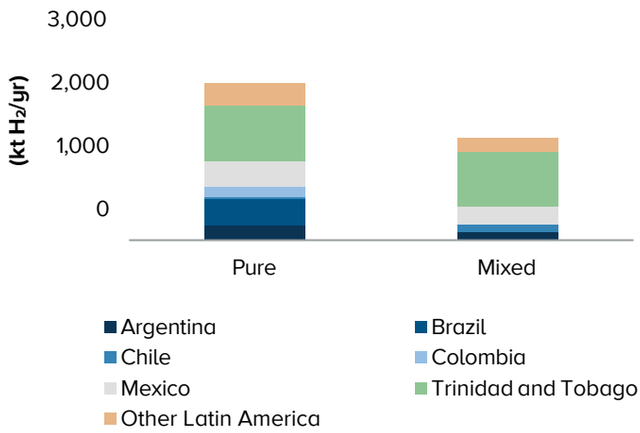
HYDROGEN PROJECTS IN LATIN AMERICA: A DUAL OPPORTUNITY

Although the relevance of the topic spreads globally, this article focuses on one region in particular – Latin America. Long seen as an emerging market, Latin America is quickly positioning itself to be a hydrogen market leader. While actual production to date has been limited, the region has multiple natural advantages and various sub-regions with hydrogen production potential that aim to become "hydrogen hubs" in the maturing global hydrogen supply chain.

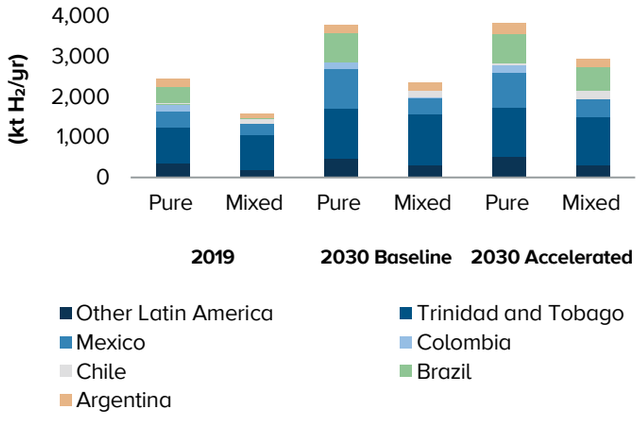
Latin American countries have various levels of industrial development, hydrogen demand and hydrogen production. Almost 90% of the region's hydrogen demand in 2019 was concentrated in the region's five largest economies (Argentina, Brazil, Chile, Colombia and Mexico), and in Trinidad and Tobago, which alone accounted for more than 40% of total demand.[1]

As global hydrogen demand rises, regional demand is expected to increase as well, from approximately 2,500kt of pure hydrogen and 1,600kt of mixed hydrogen per year in 2019, to around 3,800kt of pure hydrogen and 3,000kt of mixed hydrogen per year in 2030, as identified below by the International Energy Agency (IEA). The "2030 Accelerated" use case identified by IEA reflects an optimistic vision for the deployment of hydrogen end-use technologies and assumes the enactment of more ambitious energy and climate related policies and supporting mechanisms that could facilitate their implementation.

HYDROGEN DEMAND BY COUNTRY LATIN AMERICA, 2019



HYDROGEN DEMAND BY COUNTRY LATIN AMERICA, 2019–2030

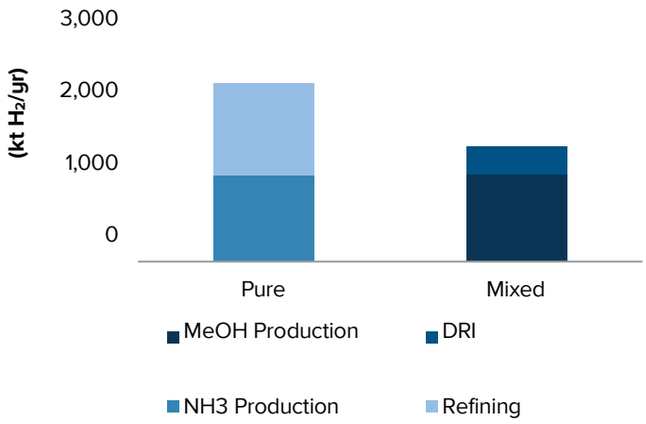


SOURCE: "Hydrogen in Latin America," IEA (2021).

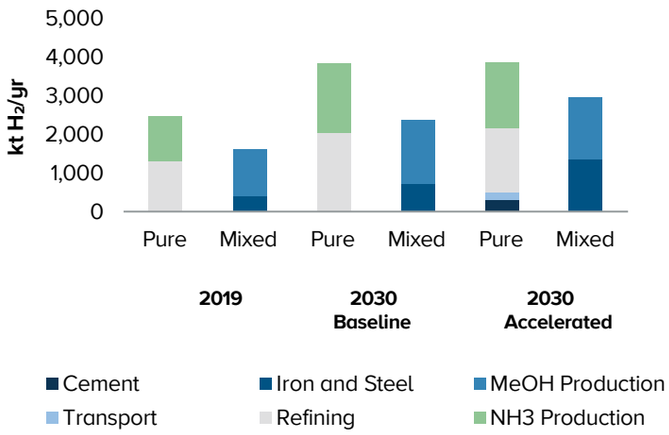
Aside from robust local demand, the dual advantage that Latin America has is the ability to produce large quantities of decarbonized molecules and to do so from a diverse range of sources. Although Latin America's industrial and oil refining sectors accounted for around 5% of global hydrogen demand in 2019, local production remains far from being green, having required more natural gas inputs than all of Chile's total gas reserves.[2] For Latin America to seize its hydrogen export opportunity, it must simultaneously shift towards lower-carbon hydrogen and fulfill local demand. There is movement in this direction already, as evidenced by projects such as Ecopetrol's first green-hydrogen pilot project at its Cartagena refinery, which is expected to use a 50kw proton exchange membrane electrolyzer, 270 solar panels and water used by the refinery to produce 20kg of high-purity green hydrogen to meet its own operational needs.[3] In Brazil, Unigel announced the start of construction of its first green hydrogen plant, which will be set up in the petrochemical complex of Camaçari, in the state of Bahia. The project has an initial announced investment of US$ 120 million and will have technology and an industrial system produced by German Thyssenkrup, with the equipment expected to be delivered in September of 2022. By 2030, local demand will likely expand to encompass further industries that currently use little or no hydrogen, such as transportation and iron, steel and cement production, creating the need for further increases in local supply.

[1] IEA, Hydrogen in Latin America, 2021.
[2] IEA, Hydrogen in Latin America, 2021.
[3] Colombia's Ecopetrol Starts Green Hydrogen Project in Cartagena

HYDROGEN DEMAND BY APPLICATION LATIN AMERICA, 2019



HYDROGEN DEMAND BY APPLICATION LATIN AMERICA, 2019–2030

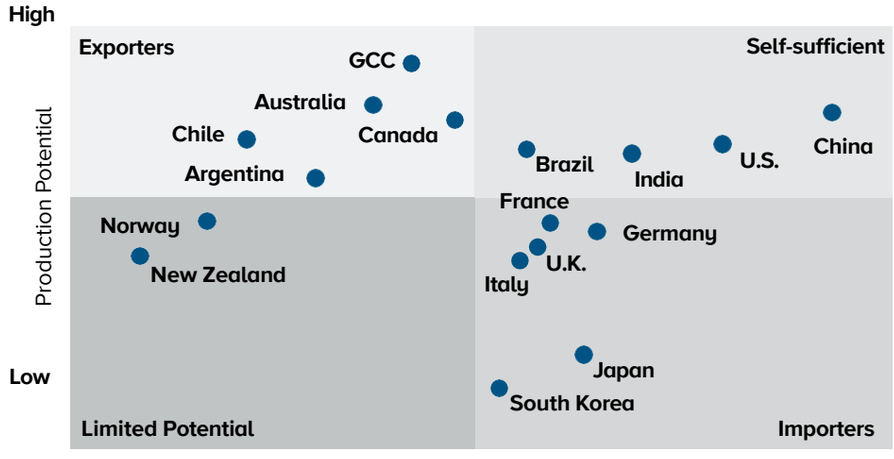


Once a local low-carbon hydrogen economy has been established and developed, the region will have the capability to export excess production to the international market. International demand will likely be driven by the commitments of developed economies — particularly Japan, South Korea, the European Union, and the United States of America — to decarbonize their energy sectors. Already, there is more than enough excess renewable energy capacity in Latin America to address a sizeable portion of this demand. Brazil, Chile and Mexico are presently among the ten largest renewable energy markets in the world in terms of investment, and there is a very strong pipeline of large-scale projects planned and under development with ample land, resource availability and political appetite to support continued growth.

Due to their ample and competitive renewable energy resources, some Latin American countries have the potential to produce more low-carbon hydrogen than their economies can consume. The countries with the greatest low-carbon hydrogen production and export potential are Brazil, Chile and Argentina, which are best positioned to become green hydrogen exporters once an international trading market develops. While Mexico has a very high degree of investment, along with Brazil the two countries produce more than 80% of the region's steel output, and Mexico is therefore predicted to consume beyond its total low-carbon hydrogen production output in the near term.

LATIN AMERICAN COUNTRIES HAVE GREAT EXPORT POTENTIAL

(Green hydrogen production, domestic consumption and export potential)



Latin America's "double opportunity" consists of both local self-sufficiency and excess capacity for export-oriented projects. The opportunities are enhanced by the region's strategic geographic location, making it a practicable partner for shipping hydrogen at internationally competitive costs.

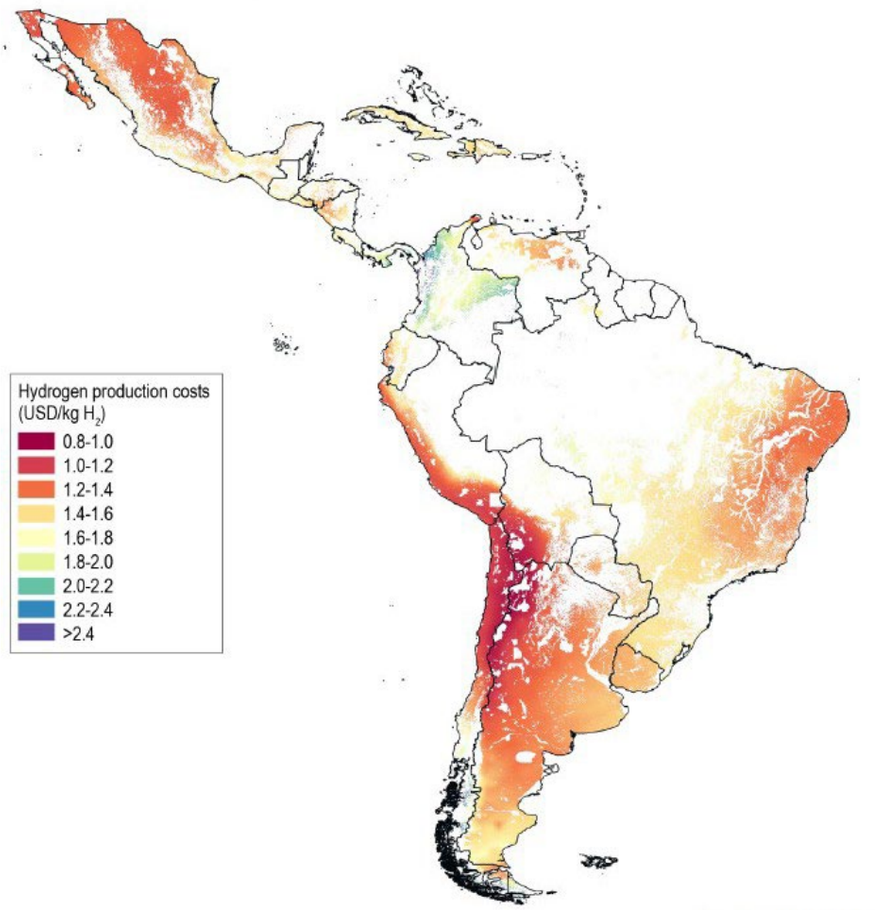
SOURCES: IEA analysis based on data from the International Fertilizer Association, Wood Mackenzie, World Street Association Steel Statistical Yearbook, Argentinian Petrochemical Institute Yearbook, ANP (Brazil), and Sistema de Información Energética (Mexico), among others.

According to a 2020 study by the World Bank's Energy Sector Management Assistance Program, the cost of green hydrogen production is estimated to be approximately (a) US$4.50-4.80/kg, assuming an alkaline electrolyzer is installed and the levelized cost of energy (LCOE) is ~US$30/MWh, or (b) US$5.00-5.80/kg, assuming a PEM electrolyzer is installed and LCOE is ~US$30/MWh. This study also revealed that at a LCOE below ~US$25/MWh, some electrolyzer companies in Chile and other Latin American countries are quoting a green hydrogen total production cost below US$3.50/kg.

With the right conditions in place, some Latin American countries could soon reach a sustainable and competitive scaled-up green hydrogen production cost. Chile for example, has announced a target price of US$1.50/kg of hydrogen by 2030. By 2023, the World Bank estimates that in the northern parts of Chile the price of green hydrogen in certain scenarios could range between US$1.80-3.00/kg. In Brazil, 85% of energy production comes from renewable sources, with increasing focus on wind and solar as alternatives for the more traditional hydro sources and the advantage of combining both sources at the same location such as in certain northeastern states. A recent McKinsey study shows that the Levelized Cost of green Hydrogen (LCOH4) produced in Brazil would be around USD 1.50/kg of hydrogen in 2030. This is in line with the LCOH of the best locations in the U.S., Australia, Spain and Saudi Arabia. According to this same study, by 2040 this cost could drop to approximately USD 1.25/kg of hydrogen.

Still, transport infrastructure must also be developed throughout the region, as the lowest production costs may be located in regions that are not well connected or are distant from current hydrogen demand hubs, such as industrial clusters. *(Note: none of the target costs quoted above account for additional expenses of ammonia synthesis, export infrastructure development, vessel chartering and other necessary export activities/infrastructure.)*

The adjacent map from the IEA showing expected hydrogen production costs demonstrates that Latin America has a land area of over 800,000km^2 in which the IEA ultimately expects hydrogen production via electrolysis to be possible under US$1/kg of hydrogen using a combined solar and wind-based energy supply by 2050. (This is consistent with the approach taken by the US$6.5 billion NEOM Helios project in Saudi Arabia). For perspective, the current U.S. presidential administration has a 2030 target of producing green hydrogen at US$1.00/kg.



HYDROGEN REGULATION IN LATIN AMERICA

Governments in the region that have identified the importance of lower-carbon hydrogen have started to develop and implement hydrogen strategies. To date, the IEA has identified thirteen Latin American countries that have either published or are currently preparing national hydrogen strategies and roadmaps.[4]

COUNTRY	POLICY DEVELOPMENTS	CURRENT SOURCES OF DEMAND	OPPORTUNITIES FOR LOW-CARBON HYDROGEN
Argentina	National 2030 strategy framework for H_2 has been published	Chemical Industry Refining	• Potential to become a low-carbon hydrogen exporter • Decarbonizing chemical industry • Decarbonizing transport
Bolivia	National energy transition strategy for Bolivia (2021-2051)	Limited use	• Decarbonizing chemical industry • Decarbonizing transport
Brazil	Assessing the role of H_2 in their National Energy Plan 2050	Chemical Industry Refining	• Potential to become a low-carbon hydrogen exporter • Decarbonizing chemical industry and refining
Chile	National strategy released in November 2020 CORFO recently awarded six green hydrogen production projects	Chemical Industry Refining	• Potential to become a low-carbon hydrogen and ammonia exporter • Decarbonizing mining industry, chemical industry and refining • Decarbonizing transport
Colombia	Recently launched an H_2 Roadmap	Refining	• Decarbonizing mining industry • Decarbonizing transport
Costa Rica	National Green Hydrogen Strategy	Limited use	• Decarbonizing industry • Decarbonizing transport • Developing industry to produce equipment/parts for hydrogen industry
El Salvador	National Development Plan: Program for the decarbonization of the Energy Sector by 2050	Limited use	• Decarbonizing power sector
Mexico	National Development Plan 2019-2024 promotes use of H_2 The Energy Transition Law establishes that 35% of electricity generation in Mexico must come from clean energy by 2024	Refining	• Decarbonizing refining industry and transport • Potential to become a low-carbon hydrogen exporter

[4] Source: IEA, local governments.

COUNTRY	POLICY DEVELOPMENTS	CURRENT SOURCES OF DEMAND	OPPORTUNITIES FOR LOW-CARBON HYDROGEN
Panama	Green Hydrogen Roadmap: H_2UB	Limited use	• Global Green Hydrogen Route • Decarbonizing industry • Decarbonizing transport • Decarbonizing agriculture
Paraguay	Conceptual framework "Towards the green hydrogen route in Paraguay" published	Limited use	• Decarbonizing heavy-duty transport
Peru	Green Hydrogen Strategy: H_2 Peru	Limited use	• Decarbonizing industry • Decarbonizing transport
Trinidad & Tobago	Launched a green hydrogen initiative	Chemical Industry	• Decarbonizing chemical industry
Uruguay	Strategy in preparation and R&D fund launched	Limited use	• Decarbonizing heavy-duty transport

SELECT LOCAL DEVELOPMENTS AND PROJECTS

Although a number of green hydrogen projects have been announced in Latin America, most of these projects are in their early stages and have received limited firm equity or debt commitments. This is likely to change, and we predict final investment decisions on several major projects within the next 24 months.

Below are some examples of various Latin American countries' hydrogen development plans:

ARGENTINA

Argentina currently has demand for around 350,000Mt/year of hydrogen, primarily from sectors such as petrochemicals, refinery processes, chemical production, and ammonia/fertilizer production for agriculture and methanol, among others. This demand is presently covered mostly with grey hydrogen (created from natural gas using steam methane reformation without capturing the greenhouse gas effluent).

The country has had a hydrogen promotion law in place since 2006, and since 2018 the parliament has been discussing boosting the development of green hydrogen. The state oil company YPF, along with CONICET (the National Council for Scientific and Technical Research) have convened a consortium of companies interested in the development of hydrogen.

BRAZIL

Brazil's hydrogen demand stood at about 400,000Mt in 2019. Virtually all of this was pure hydrogen, with oil refining accounting for 83% of total demand. The remaining volumes were used for ammonia-based fertilizer production.

Brazil has published its own safety standards for hydrogen, and since 2018 has participated in the International Organization for Standardization (ISO) hydrogen technical committee on hydrogen technologies (ISO TC 197).

In February 2021, the Brazilian National Council for Energy Policy established hydrogen as a priority area for R&D resources, and Brazil's Energy Research Office released an initial technical document establishing the basis for a national hydrogen strategy. In August 2021, the Ministry of Mines and Energy, in collaboration with other entities, presented the guidelines for a National Hydrogen Program, and exactly a year later in August 2022, the government approved a National Hydrogen Program (PNH_2). The program is aimed at strengthening the hydrogen market and industry in Brazil, as well as global export opportunities. In July 2022, BNDES announced a program to support pilot projects for the production or use of green hydrogen in Brazil. The main objective of the program is to encourage the production and storage of zero-carbon fuel in Brazil using renewable energies, while leveraging on the country's export potential.

Brazilian port complexes, including Suape in Pernambuco, Pecém in Ceará, and Açu in Rio de Janeiro are spearheading efforts to evaluate green hydrogen projects in Brazil, each having signed numerous MOUs with multinational firms.

CHILE

Green hydrogen is at the center of Chile's goal to achieve carbon neutrality by 2050. Some of the specific objectives included in the Chilean national hydrogen strategy are:

- Development of a regulatory framework to ensure safety and legal certainty.
- 5GW of electrolysis capacity built or under development by 2025.
- Production of the world's cheapest green hydrogen by 2030 (at a cost less than US$1.50/kg).
- Upgrading existing natural gas pipelines to allow for the transportation of green hydrogen.
- US$50 million in financing to develop green hydrogen projects.

Chile has identified US$12 billion in potential green hydrogen projects. As of January 2022, international energy and chemical companies producing green hydrogen had announced commitments of more than US$1 billion in investments.

MEXICO

Mexico's geography and renewable energy capacity make it well-suited for green hydrogen development, and it has a 2019-2024 National Development Plan to promote the development and use of hydrogen.

Mexico has an active renewable generation industry, although it is not strongly supported by the current administration and has suffered regulatory setbacks in the last few years. The Electric Industry Law deems the generation of power through green hydrogen and fuel cells as clean energy; however, there is no specific regulation of the sector yet. Industry players, such as the Mexican Hydrogen Association, have been actively proposing specific regulations to foster hydrogen production.

Current hydrogen use in Mexico is mainly confined to oil refineries operated by the state-owned oil company, PEMEX, and to the petrochemical industry.

The following are some of the hydrogen projects that have been announced in Mexico:

- In 2017, Air Liquide acquired the hydrogen production business unit of Pemex for US$59 million. Under the terms of the agreement, Air Liquide will supply hydrogen to PEMEX's Miguel Hidalgo refinery, based in Tula de Allende, Hidalgo State, for 20 years.
- Linde will invest approximately US$40 million into hydrogen plants at the Madero Refinery (Tamaulipas) and PEMEX will operate it. It is estimated that the plant will have a capacity to produce around 1,190,000m^3/day of hydrogen.
- Mexican company Delicias Solar, S.A. de C.V. is reportedly developing a 58MW solar power plant planned for green hydrogen generation. The plans have already been submitted to the environmental agency for an environmental impact assessment. The plant is expected to rely on approximately 140,000 solar modules and will power a 75MW hydrogen power plant with an estimated annual production of 4,425Mt.

Mexico stands to gain significantly from an effective hydrogen strategy. It is the world's 7th largest vehicle manufacturer and 15th largest steel producer. As highlighted earlier, steel production is responsible for considerable amount of GHG emissions — if it were a country, steel would be the third largest emitter of CO_2 behind the U.S. and China. The industry is therefore under intense pressure — including from customers such as car makers — to lower its GHG emissions. Steel production emits such high volumes of GHGs because the process itself requires fossil fuel-powered thermal power and because the by-product of the smelting process produces CO_2. The steel industry is ripe for decarbonization because it requires very few new technological inputs in order to replace fossil fuels. Instead of using coal to separate the oxygen molecules from the iron ore, an alternative process simply substitutes coal with hydrogen, which not only separates the oxygen molecules, but produces only water vapor as a by-product instead of CO_2.

At present, Mexico's plans and emissions targets have been rated by the Climate Action Tracker as "highly insufficient" to meet the warming limitations goal of the Paris Agreement. In its updated Nationally Determined Contribution, Mexico did not revise its targets and its emission projections remain likewise unchanged. Decarbonizing its steel industry would allow the country to better meet international net-zero emission goals without compromising on the competitiveness of its steel and automotive industries.

REGIONAL DEVELOPMENTAL CHALLENGES

REGULATORY CHALLENGES

The lack of comprehensive, integrated regulation and regulatory strategies for the production and commercialization of low carbon hydrogen currently limits the development of the entire industry in Latin America. There is not yet complete market consensus on the criteria for description of hydrogen as "green," nor are there widely accepted, objective carbon limits for describing hydrogen as "blue" or "low-carbon." This results in legal and market risks that investors have to consider before investing significant capital.

The lack of clarity with regard to local regulations and global definitions in this industry drives up the time and cost of engineering, as projects have to be structured conservatively in order to mitigate the risk that future regulation will demand greater reductions on carbon intensity or use of electricity and water. This conservative structure potentially reduces the operating efficiency of the projects, making the end-use hydrogen unnecessarily more expensive and may therefore curtail demand.

INFRASTRUCTURE CHALLENGES

A second obstacle to widespread adoption and commercialization of green and blue hydrogen in Latin America is the slow pace of development of strategic infrastructure, particularly for hydrogen transportation. Several industry players in the region are moving towards developing hydrogen infrastructure, but the lowest production costs for green hydrogen may be located in remote regions that have not been well connected or are distant from hydrogen demand or export hubs. This strategic infrastructure issue must be addressed in order to develop a regional hydrogen market, reduce production and transportation costs, and establish the necessary supply for eventual international export.

OFFTAKE

There is currently no international market for green or low-carbon hydrogen, and developers and lenders alike are grappling with how to manage the associated market risk exposure. To be considered bankable, green hydrogen projects generally require long-term offtake contracts with creditworthy off-takers, structured on a take-or-pay basis, similar to early LNG projects.

On the import side, there have been recent announcements of new projects and commitments, particularly in Asia where Japan and South Korea are betting heavily on hydrogen to meet their clean energy goals. For Japan, hydrogen is considered "indispensable" to meet its zero-emissions targets and is expected to account for 40% of its energy portfolio by 2050. Australia, earlier this year, delivered the world's first liquid hydrogen shipment to Japan's terminal in Kobe. Japan expects to import up to 300,000Mt/year of hydrogen by 2030, and 36,000,000Mt/year by 2050.

In Korea, the Korea Gas Corporation, the biggest LNG importer in the country, expects to complete demonstration projects to blend 20% hydrogen in its natural gas pipelines by 2026, and by 2027, intends to start importing hydrogen. By 2050, South Korea expects hydrogen to account for 20% of its national energy mix. The country is the 6th ranking steel manufacturer in the world and is relying on hydrogen to reduce GHG emissions. Posco, the country's largest steel manufacturer, expects to import 80% of its hydrogen demand by 2050.

Perhaps most significantly, the European Union intends to import 10,000,000Mt/year of hydrogen by 2030, which is expected to rise to 60,000,000Mt/year by 2050. Germany's largest utility, E.ON, recently signed a memorandum of understanding alongside the German government with Australian green hydrogen project developer Fortescue Future Industries, for the purchase of 5,000,000Mt/year of green hydrogen from 2030 onwards. This amount is equivalent to one-third of the total calorific value of fossil fuel-based energy that Germany imported from Russia prior to Russia's invasion of Ukraine in the spring of 2022.

On the export side, Chile has plans to deliver hydrogen to the Port of Rotterdam in the Netherlands based on a 2021 framework agreement to pursue the possibility of creating a hydrogen corridor between Chile and Europe. Singapore has also signed an agreement to assess the viability of routes from Chile and other Latin American countries. Chile's Ministry of Energy has also met with investors from Germany, Australia, Canada, China, the United States, Japan and the United Kingdom for potential investment opportunities; such is the keen interest in Chile's hydrogen projects.

Presently, there is a limited pool of creditworthy off-takers with the risk appetite and downstream distribution network to offtake green or low-carbon hydrogen at utility scale. It is difficult for producers to commit to steady and predictable production volumes because of the need to rely on renewable power sources, making commitment arrangements complex.

RISKS

For all its benefits in helping achieve net-zero emission targets and creating export opportunities for much of Latin America, hydrogen is a volatile gas that poses risks that need to be taken seriously. Hydrogen leaks must be kept to a minimum throughout the supply chain, otherwise it risks exacerbating the very problem it is being manufactured to solve. To this point, scientists consider that hydrogen, when released in air, acts as an indirect GHG by setting off a chain of chemical reactions that can ultimately be greater than 33 times more potent than CO_2 in trapping atmospheric heat.

CONCLUSION

Although multiple countries in Latin America possess the right conditions to become green hydrogen producers and exporters, the next decade will be crucial for the long-term prospects of green hydrogen, both for local consumption and exportation. In this regard, hydrogen-specific regulation will be fundamental to provide clarity and legal certainty for the development of these projects. Latin American countries are working to position themselves front-and-center as producers to the world, and only time will tell how much demand will materialize.

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