H2U

Green Hydrogen
Roadmap in Uruguay

Ministerio
de Industria,
Energía y Minería

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H2U

INTERINSTITUTIONAL GROUP:

Ministerio **de Industria, Energía y Minería**
Ministerio **de Relaciones Exteriores**
Ministerio **de Economía y Finanzas**
Oficina **de Planeamiento y Presupuesto**

Ministerio **de Transporte y Obras Públicas**
Ministerio **de Vivienda y Ordenamiento Territorial**
Ministerio **de Ambiente**

ADMINISTRACIÓN NACIONAL DE PUERTOS
República Oriental del Uruguay

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WITH THE SUPPORT: BID
Mejorando vidas

This document is the result of the work of the interinstitutional group, coordinated by the MIEM, with the support of the IADB during 2021 and early 2022.

This document is under consultation as from the date of its presentation (June 2022) until the date reported at www.hidrogenoverde.uy.

Comments and contributions can be sent to the following e-mail address: hidrogeno@miem.gub.uy.

This report has been prepared with special concern for the use of expressions and concepts that do not exclude people based on their gender.

The reference to this document is: Green Hydrogen Roadmap in Uruguay, MIEM 2022.

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This document is a technical input prepared by the above-mentioned interinstitutional group so that the Uruguayan State can design the necessary public policies to develop the green hydrogen industry. In any case, this document is not legally binding.

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ACRONYMS

ANCAP ________________ National Administration of Fuels, Alcohol and Portland (*in Spanish, Administración Nacional de Combustibles, Alcohol y Pórtland*)
ANII ________________ National Agency for Research and Innovation (*in Spanish, Agencia Nacional de Investigación e Innovación*)
ANP ________________ National Ports Administration (*in Spanish, Administración Nacional de Puertos*)
CONICYT ________________ National Council for Innovation, Science and Technology (*in Spanish, Consejo Nacional de Innovación, Ciencia y Tecnología*)
DRI ________________ Direct Reduced Iron
ESG Factors ________________ Environment, Social and Governance Factors
GDP ________________ Gross Domestic Product
GW ________________ Gigawatt
Gt ________________ Gigatons
e-Jet Fuel ________________ Aviation fuel, in this case, made from green hydrogen
IADB ________________ Inter-American Development Bank
IMO ________________ International Maritime Organization
LATU ________________ Technological Laboratory of Uruguay (*in Spanish, Laboratorio Tecnológico del Uruguay*)
MEF ________________ Ministry of Economy and Finance (*in Spanish, Ministerio de Economía y Finanzas*)
MIEM ________________ Ministry of Industry, Energy and Mining (*in Spanish, Ministerio de Industria, Energía y Minería*)
MVOT ________________ Ministry of Housing and Land Management (*in Spanish, Ministerio de Vivienda y Ordenamiento Territorial*)
MRREE ________________ Ministry of Foreign Affairs (*in Spanish, Ministerio de Relaciones Exteriores*)
Mt ________________ Megatons
MTOP ________________ Ministry of Transportation and Public Works (*in Spanish, Ministerio de Transporte y Obras Públicas*)
Offshore Wind Energy ____ Energy generated by sea-based wind turbines
Onshore Wind Energy ____ Energy generated by land-based wind turbines
OPP ________________ Planning and Budget Office (*in Spanish, Oficina de Planeamiento y*
________________ *Presupuesto*)
SAF ________________ Sustainable Aviation Fuel
SDGs ________________ Sustainable Development Goals
SYNFUEL ________________ For this document, synthetic fuel made from green hydrogen
TCO ________________ Total Cost of Ownership
URSEA ________________ Energy and Water Services Regulatory Unit (*in Spanish, Unidad Reguladora de Servicios de Energía y Agua*)
USD ________________ United States Dollar
UTE ________________ National Administration of Power Plants and Electrical Transmissions (*in Spanish, Administración Nacional de Usinas y Transmisiones Eléctricas*)

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FOREWORD

I am pleased to address you to talk about the roadmap that Uruguay is making public to become a leading country in the production and export of green hydrogen.

This document is the result of hard work carried out by a fantastic group of collaborators from different organizations, whom we would like to especially thank for their commitment and professionalism. I would like to highlight the support provided by the Inter-American Development Bank for the collaboration of its high-level technical staff and for providing us with sound information for decision-making.

The preparation process also included a series of roundtables with stakeholders directly involved in the field, both from the public and private sectors, as well as from the academia. It was also based on feasibility studies conducted by a renowned international consulting firm.

So, why green hydrogen? Why now?

Shortly after taking office as Minister of Industry, Energy and Mining, I had the pleasure of receiving several delegations that were beginning to position green hydrogen as the key to accelerating the global energy transition. Uruguay was already taking the first steps towards the decarbonization of its heavy and long-distance transport matrix.

Hydrogen is one of the most abundant resources on the planet and is regularly used in different industrial processes. It is a vector capable of storing and transporting energy and inputs or with minimum environmental impact. This is why the European Union, the United States, the United Kingdom and Japan (among others) have selected hydrogen as one of the main vectors for decarbonizing those sectors of the economy that have the greatest difficulty in reducing their climate footprint.

Hydrogen enables the electrification of long-distance and cargo land transport, but also its application through known chemical processes allows the production of green fuels such as methanol from renewable sources, ammonia, green kerosene, and synthetic diesel. These green fuels and chemicals are the ones that enable the decarbonization of maritime and air transport, fertilizers, steel, and cement production, among others.

The process to achieve the energy transition is gaining momentum worldwide, through strategies such as electromobility (a path that Uruguay has already started) and green hydrogen. Significant funds have been committed to the development of a hydrogen economy and it is a strategic aspect on the agenda of both major countries and global companies. Energy geopolitics is beginning a process of transition towards greater diversification, in which countries that historically have not had relevant energy resources are positioning themselves as new players with diverse roles and possibilities.

Uruguay faces a unique opportunity to expand the country's energy production and export boundaries. The first energy transition has shown us the potential of renewable energy production and has strengthened our credibility as a recipient country for large-scale investments. We seek to move from sun and wind to hydrogen, which will allow us to produce exportable synthetic fuels, as well as other derivatives, and hence green fertilizers that can drive sustainable production, spilling over to other sectors of the economy, both at the industrial and agricultural levels.

Developing the green hydrogen and derivatives production chain for the export and domestic markets will allow us to leverage the fulfillment of the Sustainable Development Goals and, on the other hand, strengthen our efforts to achieve our climate commitments, creating job opportunities and improving the sustainability of our economy. How can we take advantage of this opportunity and provide agents with the right incentives?

That is what this roadmap, based on our potential, intends to answer: to propose ambitious goals for 2040 and to join the efforts of various government agencies, together with the private sector, to achieve the objectives. The challenge is a big one, with many questions to be addressed. In any case, Uruguay has a rich tradition of public policy-making based on solid technical studies, strategic planning and the collaboration of all stakeholders (public and private) in achieving the goals set.

This roadmap is a first step to start setting a course in dialogue with many other stakeholders and, in parallel, to drive concrete actions through the development of a specific program called H2U. Regulations and incentives have already been developed to promote the domestic production of the first green hydrogen molecule, which will allow us to gradually create capabilities and knowledge, as well as greater opportunities for society as a whole.

Finally, I invite everyone to participate in the consultation of this document in order to enhance the work done, and thus accelerate the second energy transition.

Omar Paganini,
Minister of Industry, Energy and Mining

1.
Executive Summary

1. EXECUTIVE SUMMARY

The ambitious decarbonization goals for 2050, established at a global level, make it necessary to promote accelerated and significant changes, both in terms of the energy sources used and the use of raw materials consumed in different industrial processes.

On the other hand, the energy transition sought implies that countries highly dependent on a few fossil energy suppliers will need to diversify their renewable energy sources, which will give them greater resilience over time as well as reduced future risks. Within this framework, green hydrogen, produced from water and renewable energies and with the capacity to decarbonize different uses (transport, thermal energy, industrial energy, raw materials and stabilization of highly renewable electricity grids) has positioned itself as an energy vector of great relevance in the global agenda, especially for those sectors where decarbonization through electric energy is very complex (hard to abate sectors). In a projected scenario of high demand in both Europe and East Asia, some countries will be importers and other countries will be exporters of low-emission hydrogen. Uruguay is among the latter, with conditions that make it very competitive.

Our country has practically decarbonized its electricity matrix, positioning itself in a prominent position worldwide, with a 97% share of renewable energies (2017-2020 period). The quality, abundance and complementarity of wind and solar resources would allow this process to continue and thus achieve competitive costs for hydrogen production at scale. By 2030, production costs may reach 1.2-1.4 USD/kg, with total capacity exceeding 90 GW of power from renewable energy at sites with the highest potential.

In addition, the country has hydroelectric power plants, electricity transmission grid infrastructure and easy access to biomass, which can enable competitive production of synthetic fuels (e-methanol and e-Jet Fuel). It is worth highlighting the port of Montevideo with access to the Atlantic Ocean and the current developed internal logistics operations, as well as Uruguay's financial strength, which creates favorable conditions for the development of new infrastructure.

Uruguay has a high availability of fresh water given that it is part of a large regional basin and due to its annual rainfall regime. The water demand required for the production of green hydrogen proposed in this roadmap is significantly lower than the current demand of agricultural and industrial sectors in the country.

Taking into account the potential of resources and the established goals, hydrogen production could be close to one million tons per year by 2040. This will require the installation of 20 GW of renewable energies and 10 GW of electrolyzers. In the first phase, the export of synthetic fuels and green fertilizers will be promoted, which will help boost the domestic market by targeting long-distance heavy transport. It will be necessary to create incentives and regulations as well as to analyze future infrastructures that will create the conditions for a next phase in which green hydrogen and ammonia can be exported.

Green hydrogen and its derivatives represent a 2.1-billion-dollar annual revenue opportunity for Uruguay by 2040, driven by the synthetic fuel and hydrogen export markets as well as by the use of hydrogen for the deep decarbonization of its economy (in the transport, pulp and paper, shipping and agriculture sectors).

The development of the green hydrogen industry could create more than 35,000 direct skilled jobs in plant construction, operation and maintenance, logistics and technical education.

Decades of experience in the development of renewable energy projects; solid regulatory frameworks; political, institutional and legal stability; and solid macroeconomic stability make Uruguay an attractive location for foreign investment, particularly for the development of hydrogen projects, many of them on a large scale.

The development of a green hydrogen economy at national level will contribute to the diversification of the national productive matrix, increasing the added value through a new industrial link and developing the export potential to new markets worldwide, thus making a significant contribution to economic development.

The Government of Uruguay places green hydrogen as a priority instrument in its sustainability program and is committed to promoting the corresponding regulation, the streamlining of permits, a set of attractive incentives and the analysis of the infrastructure necessary for its development along with its eventual promotion in the future.


Itaporá Farm

2.

Collaboration and Methodology

2. COLLABORATION AND METHODOLOGY

Uruguay began working on the development of green hydrogen in 2018, upon the creation of an initial interinstitutional group made up of the Ministry of Industry, Energy and Mining (MIEM) and the state-owned energy companies ANCAP and UTE. In this first stage, the development of green hydrogen was seen as a natural step for the country, after having completed the decarbonization of the electricity matrix. The medium and long-term opportunities that would be created in the decarbonization of the energy sector (heavy road, maritime and air transport; industry, etc.) and of raw materials were anticipated, in addition to the advantage of being an energy vector that allows renewable energy to be distributed among sectors and regions. At that time, emphasis was placed on the analysis of green hydrogen production from renewable energies and its use in heavy and long-distance transport, in what was called the Verne Project.

In 2020, the interinstitutional hydrogen group was expanded to include other ministries and State institutions. Currently, it is made up of the MIEM, the Ministry of Environment (MA), the Ministry of Economy and Finance (MEF), the Ministry of Transportation and Public Works (MTOP), the National Ports Administration (ANP), the National Agency for Research and Innovation (ANII), Uruguay XXI, ANCAP, UTE and the Technological Laboratory of Uruguay (LATU). In that same year, work was carried out together with the Port of Rotterdam (PoR), the Netherlands, to conduct preliminary studies that helped to visualize Uruguay's potential as a producer and exporter of green hydrogen and derivatives to Europe and especially to the PoR. Throughout the entire process, the Inter-American Development Bank (IADB) provided constant support and close collaboration until the first conclusions of the work were published (IADB, 2021).

During 2021, also with the support of the IADB, progress was made in the development of this roadmap. First, McKinsey & Company was hired (in accordance with contract C-RG-T3777-P001 concluded with the IADB) to conduct technical studies to support this document. Full details of these studies will be publicly available. As part of this process, three exchange instances were held with relevant actors in the sector (discussion roundtables), which included the participation of more than 70 representatives from the national and international spheres in each instance. The scope of each one of them is detailed below.

Roundtable 1: ***Supply and Demand of Green Hydrogen and Derivatives.*** Production costs in Uruguay: levelized cost of energy (LCOE), levelized cost of hydrogen (LCOH) and cost of hydrogen derivatives. Potential domestic and export market.

Roundtable 2: ***Enablers and Barriers.*** Regulatory aspects, permits, financing, bilateral agreements, required infrastructure, talent, and social license.

Roundtable 3: ***Initial Green Hydrogen Roadmap Proposal.*** Key milestones, socio-economic benefits, risk analysis.

After a process of analysis and exchange with relevant actors at national and international level, it is concluded that Uruguay has very good conditions for the development of green hydrogen and derivatives, both for local commercialization and export. Based on this conclusion, the present roadmap to 2040 is proposed.

3.
Why **Green Hydrogen?**

3. WHY GREEN HYDROGEN?

Green hydrogen is key to achieving ambitious global decarbonization goals, particularly for those sectors where it is most difficult to reduce greenhouse gas emissions. Hydrogen is highly versatile as it can be used directly or combined with other elements to produce new products. It can be used in the land, sea and air transport sectors as well as for industrial and domestic purposes and for the stabilization of renewable energy systems.

3.1 - Global situation

According to studies by the Intergovernmental Panel on Climate Change (IPCC), to limit global warming to less than 1.5°C, the world must achieve carbon neutrality by 2050 (IPCC, 2018).

Fossil fuels account for 80.2% of global energy consumption (Renewables - REN 21, 2021). Their demand will continue to increase as the world's population continues to grow and greater economic development is projected. Therefore, it is both urgent and a priority to accelerate a low-carbon energy transition.

At the global level and within the framework of the Paris Agreement (2016), in the context of the United Nations Framework Convention on Climate Change, each country sets measures for the reduction of greenhouse gas emissions. Many have already set the goal of being carbon neutral by 2050 (United Nations, Climate Change, 2022) and regulations are being developed in this regard (European Commission– Climate Action, 2022).

Accordingly, industries are making announcements along these lines. The major brands in the automotive industry have announced that their vehicles will be zero-emission by 2050, and some of them even earlier (General Motors, 2022). Shipping and aviation companies have begun to develop their decarbonization plans to gradually incorporate hydrogen and synthetic green fuels into their fleets (Maersk, 2022; Airbus, 2022; Boeing, 2022).

Other energy industries have also announced that they will be zero-emission by 2050, including companies that have their core business in the sale of hydrocarbons (Shell, 2022; British Petroleum, 2022).

Hydrogen, generated from low-emission energy sources, plays a central role in achieving net-zero emissions by 2050. It can avoid 80 gigatons (Gt) of cumulative carbon dioxide (CO2) emissions and 20% of the reduction needed by 2050. This requires the use of 660 million tons of renewable and low-carbon hydrogen, equivalent to 22% of global final energy demand in 2050 (McKinsey & Company, 2022).

The estimated demand for hydrogen and its derivatives in Europe and some Asian countries is so high that it will be necessary to import it from farther afield in order to meet the goals set (World Energy Council, 2021).

3.2 - Green hydrogen roles in energy transition

Green hydrogen contributes in various aspects to the energy transition that is underway to ensure compliance with the environmental goals set for the year 2050. The main contribution that has been identified is that its production and use would allow the decarbonization of energy and raw material end uses that are difficult to achieve in other ways or that cannot be achieved directly with renewable energies or through direct electrification.

On the one hand, the use of this energy vector would enable the distribution of energy to other sectors. Thus, starting with electricity from renewable sources, it would be possible to produce hydrogen and use it in applications that include a wide variety of uses, such as the synthesis of ammonia for fertilizers; the production of fuel for mobility in heavy vehicles and hydrogen derivatives for maritime and aviation use; the production of industrial heat; in some climatic conditions, the thermal conditioning of buildings; and the direct reduction of iron for steel production, etc. (see Figure 1).

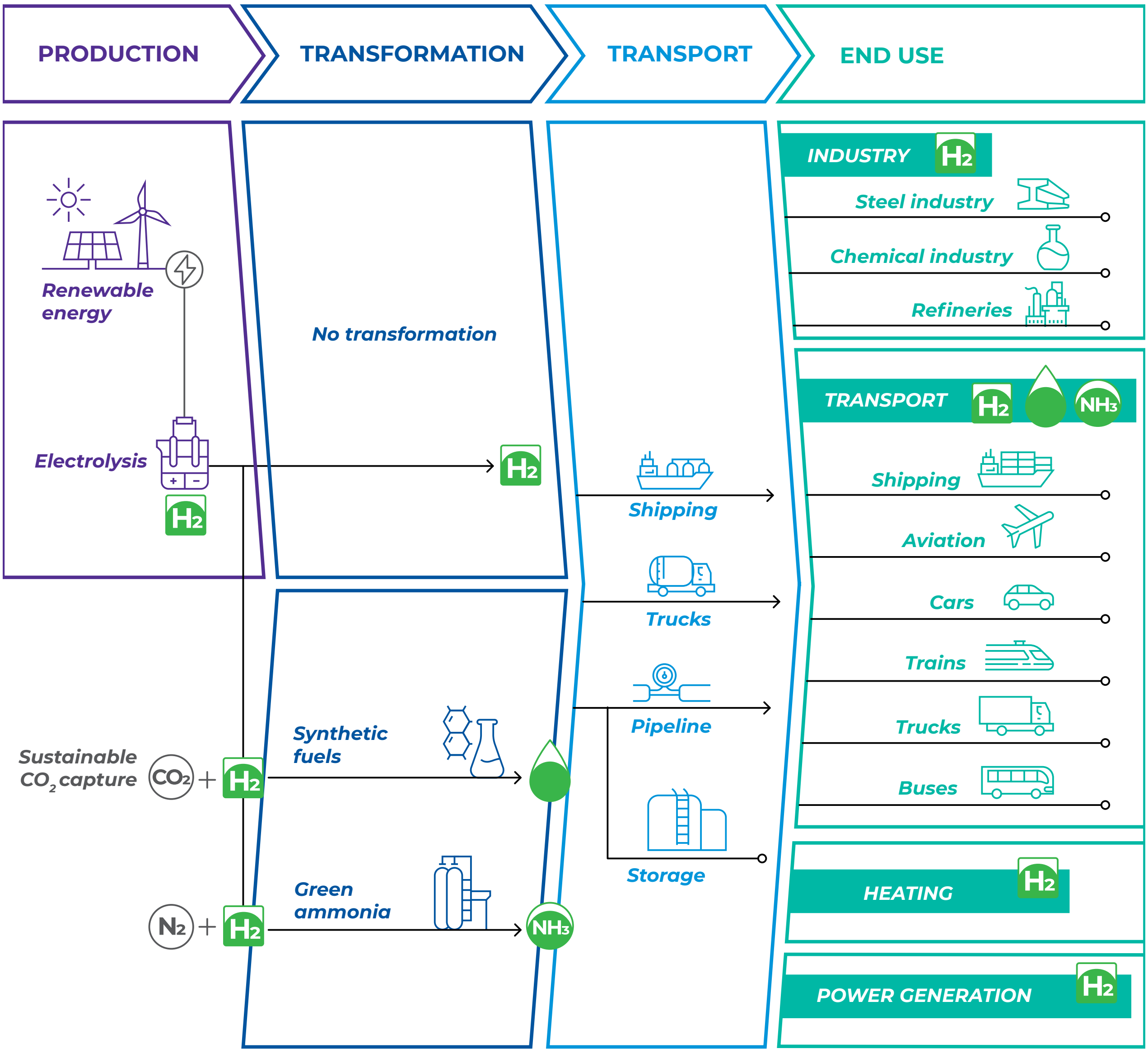


Figure 1: Hydrogen uses in different sectors as a source of energy or raw material.

Source: Based on document from the International Energy Agency, "Green Hydrogen: A guide to policy making" (International Renewable Energy Agency, 2020).

Another way in which green hydrogen would contribute to energy transition relates to increasing the resilience of the energy system by enabling the integration of renewable energies on a large scale.

The use of green hydrogen and its derivatives as energy vectors would contribute to the transport of green energy between regions, as they could be moved inexpensively over long distances, similar to what happens today with other energy sources (e.g., oil or liquefied natural gas). In this way, it would be possible to transport renewable energies in the form of green hydrogen, derivatives or green products from regions of the planet that have the possibility of producing plenty of renewable energies inexpensively to areas with insufficient resources (or surface area for their transformation) or where it would otherwise be too expensive to produce them. The accumulation of hydrogen in large quantities and for long periods would increase the share of renewable energies in the energy system and contribute to the continuous operation of the grid, thus balancing the peaks and valleys of electricity demand, and storing energy at times of high availability and low cost for delivery at times when demand requires it. It would also contribute to the diversification of energy resources in the different regions, by facilitating the use of the most attractive and profitable resources. It would also provide greater security to distributors when it comes to ensuring continuous supply to essential facilities (e.g., health services and data centers, among others) (Hydrogen Council, 2021).

Within the electricity sector, it would also enable, in a complementary way, the generation of electricity from hydrogen, thus helping to achieve seasonal balance, backup for variable renewable sources and continuous operation at plant base. On the other hand, it would help countries that cannot generate their own electricity from renewable sources to import green hydrogen and use it as an input in this electricity generation activity from renewable sources (Hydrogen Council, 2021).

Finally, green hydrogen would contribute to the ongoing transition by providing countries with greater energy security in the medium term, since it can be produced locally or, eventually, be imported from a significant number of producing countries distributed across multiple geographic regions. This would help achieve stable and decreasing costs over time. The above is in contrast to the current energy system, in which fossil fuels (80% of the world's energy matrix) (Renewables - REN 21, 2021) are produced by a limited number of countries, at prices subject to variations due to causes beyond the control of importers.

4.
Why **Green Hydrogen** in Uruguay?

4. WHY GREEN HYDROGEN IN URUGUAY?

In Uruguay, the development of green hydrogen is a natural step in its decarbonization process, after having significantly reduced the use of fossil fuels in the electricity matrix. In addition, the country has important competitive advantages to be a relevant producer of green hydrogen and derivatives, both for the local market and for export.

4.1 - A country that promotes sustainable strategies

In what is identified as the first stage of its energy transformation, Uruguay has practically achieved the decarbonization of electricity generation. The above translates into an average 97% share of renewables in the electricity matrix in the 2017-2020 period (53% wind, solar and biomass and 44% hydroelectric), although the figure varies depending on the climatic characteristics of each year (see Figure 2).

In this way, the country has significantly reduced greenhouse gas emissions from the energy sector.

The second stage of the energy transition in Uruguay includes, among other challenges, the decarbonization of the rest of the energy sector (transport and industry), as well as of raw materials for industrial use, the development of a hydrogen economy, the maintenance of the high share of renewable energies in the electricity matrix and a more efficient use of the electricity system.

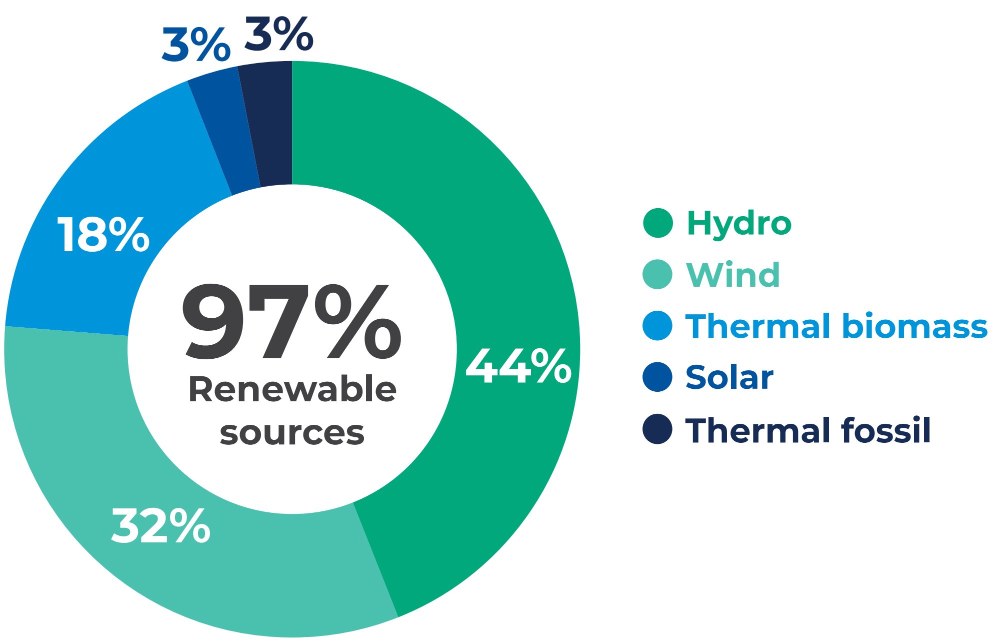


Figure 2: Electric power generation in Uruguay - Average for the years 2017 to 2020..

Source: MIEM (ben.miem.gub.uy).

4.1.1 - Energy policy and first stage of the transition

In 2008, Uruguay presented its energy strategy, which explicitly states its commitment to renewable energies and energy efficiency. This policy aims, on the one hand, to move beyond the traditional reductionist view based on technical-economic analysis, by exclusively incorporating the geopolitical, environmental, social, ethical and cultural dimensions into the analysis. On the other hand, this public policy promotes a long-term vision and planning. Perhaps its most relevant milestone is the agreement reached in 2010 between all the political parties represented in parliament, which laid the foundations for the development of a State policy in the sector.

As a result of the implementation of this policy, Uruguay has practically decarbonized its electricity matrix, supplementing the traditional share of hydro energy with the incorporation of wind, solar and biomass energy.

The high penetration of renewable energies in the electricity matrix has positioned Uruguay as a world-class player in the energy transition. The country is ranked 13th in the Energy Transition Index and is the leader in the region (World Economic Forum, 2021).

In line with its sustainable policy, Uruguay has proposed a Long-Term Climate Strategy to 2050 (Ministry of Environment of Uruguay, 2021), in which green hydrogen and its derivatives are used for heavy cargo and long-distance passenger transport, as well as for some industrial uses. Therefore, both for domestic consumption and for export, green hydrogen will play a relevant role for the country in the short and long term.

4.1.2 - Sustainability policies

Uruguay has a broad and robust package of sustainable development public policies, covering climate action, energy, agricultural production, and waste.

Historically, and regardless of political orientations, the work has been promoted in a cross-cutting manner, articulating between production and environment ministries, with the understanding that sustainability can only be developed in an integrated and coherent manner with the other dimensions of development, including the social dimension. Examples include energy, climate change and forestry policies, as well as the soil law, among others.

Giving continuity to the relevance of environmental issues at the State policy level, in 2020 the Ministry of Environment was created to add actions that prioritize sustainability issues to the agenda and give them greater institutional strength.

Uruguay, working transversally at the level of all ministries, autonomous entities, and decentralized services, has undertaken the responsibility of guiding its public policies towards the fulfillment of the Sustainable Development Goals (SDGs), with the aim of advancing in each one of them towards the year 2030. Since 2017, Uruguay has been submitting voluntary reports and has completed the monitoring of the country situation in each of the 17 SDGs (Presidency of the Republic, 2021).

Boosting green H2 will accelerate progress on SDGs 7 (Affordable and Clean Energy), 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities) and 13 (Climate Action) and will indirectly contribute to other goals.

4.2 - Competitive advantages for the development of green hydrogen and derivatives

The following is a description of the main competitive advantages of Uruguay as a relevant producer of green hydrogen and derivatives, both for the local market and for their export.

4.2.1 - Potential and complementarity of renewable energies

Uruguay has great potential to install new electric power generation capacity from renewable sources, mainly wind and solar photovoltaic. The country has a very good, combined wind and solar resource, both for its daily and seasonal complementarity; this results in high electrolyzer capacity factors and low hydrogen production costs.


Peralta Wind Farm

According to studies carried out, the characteristics of solar and wind renewable energies in Uruguay would make it possible to reach, by 2030, levelized costs of energy (LCOE), with values ranging from 16 to 19 USD/MWh. On the other hand, offshore wind energy would have costs in the range of 26 to 28 USD/MWh.

Driven by Capex reductions and technological improvements, the downward cost trend would be maintained over time (although its decline would slow down), reaching costs of up to 11 USD/MWh in 2040 for the use of solar resources through photovoltaic technology, 15 USD/MWh for wind resources and 21 USD/MWh for offshore wind resources.

The studies carried out identify regions of the country with different potential for the generation of renewable energies (level I and level II). The regions having the best characteristics (capacity factors between 25% and 28%) for solar photovoltaic energy (level I) are located in the west of the country, in the departments of Artigas, Salto, Paysandú, Río Negro, Soriano and Colonia. The area available for the development of solar photovoltaic plants in level I has an associated capacity of 60 GW. The central areas (between Rivera and Canelones) have medium quality resources (level II, with capacity factors between 20% and 24%) with an additional 135 GW potential.

Likewise, for the development of onshore wind power plants, Uruguay has a 30 GW capacity in high quality areas (level I, with winds of 8-9 m/s), located in the limit between the departments of Rivera, Tacuarembó, and Salto, and between Lavalleja, Florida and Treinta y Tres. The rest of the territory has medium quality characteristics (level II, with winds of 7-8 m/s) and would allow for an additional generation capacity of 50 GW (McKinsey & Company, 2021).

The area available for offshore development would enable the installation of an additional 275 GW capacity (World Bank, 2020).

The costs shown below reflect the range of level I - level II resources.

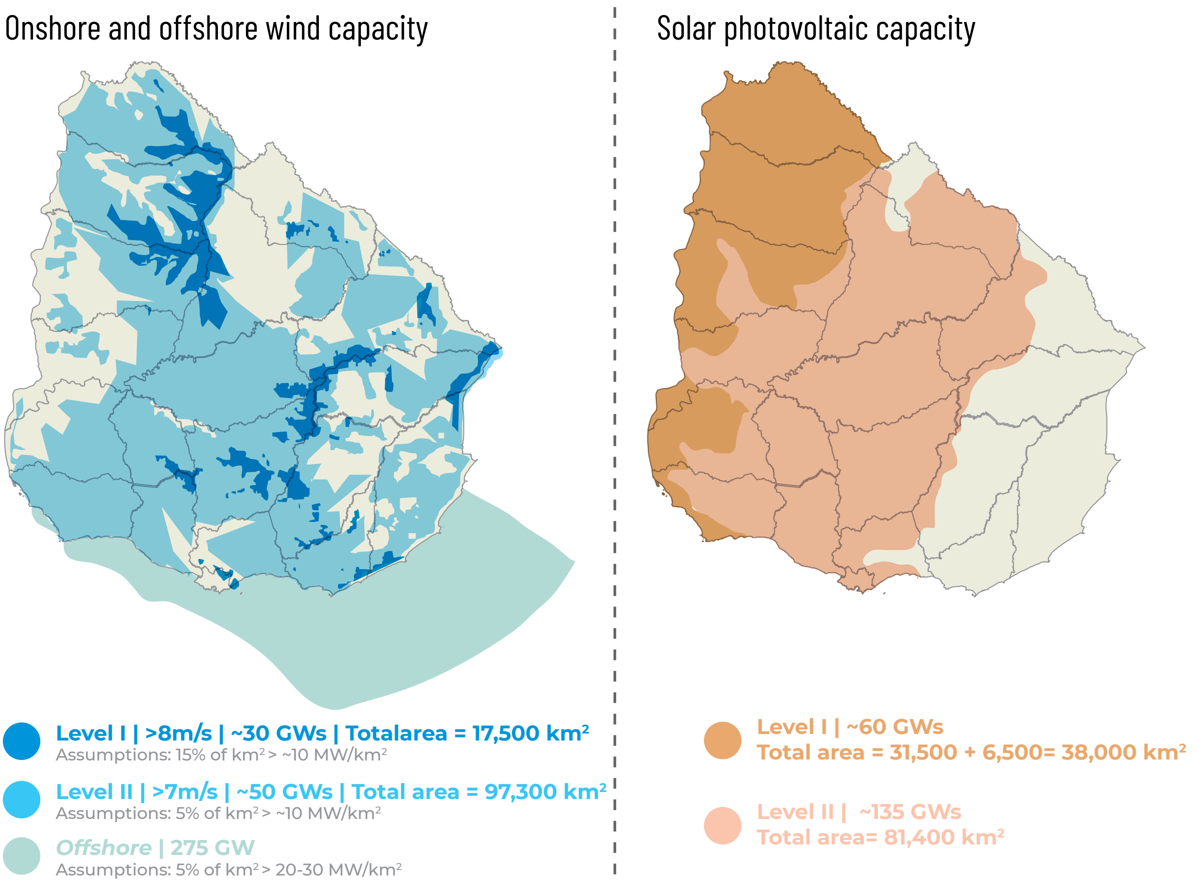


Figure 3a: Potential capacities (GW) by renewable source.

Source: Atlas Solar, MIEM, McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

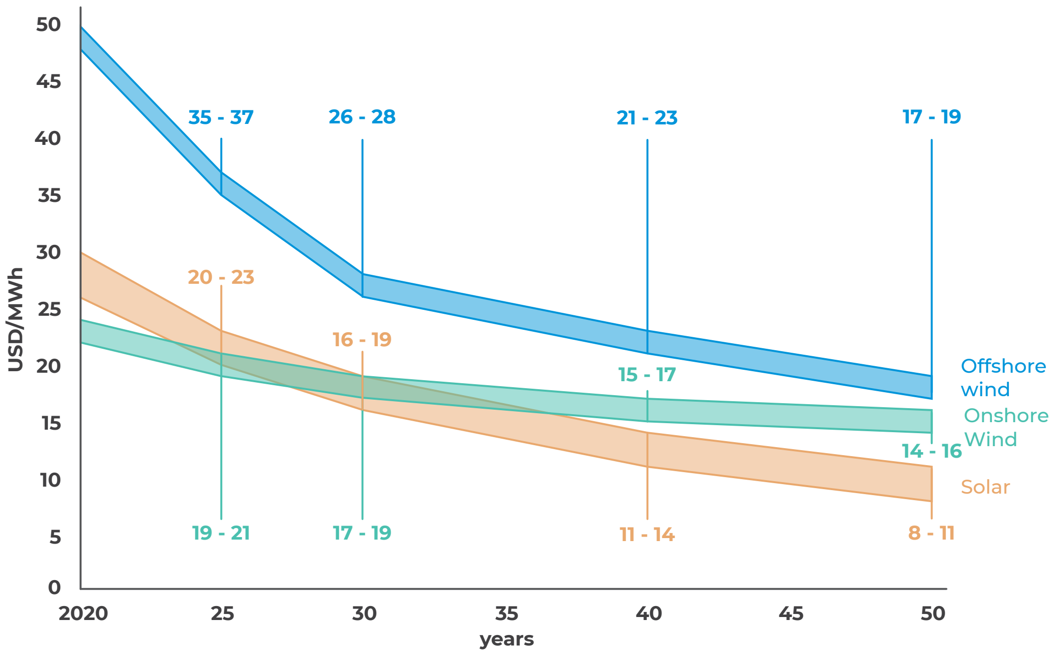


Figure 3b: Levelized cost of energy (based on 5% WACC, does not include transportation costs) at scale (+500 MW), USD/MWh.

Source: Adapted from McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

4.2.2 - Electricity matrix with 97% share of renewables

For industrial processes that need to run on a continuous basis (e.g., the production of e-Jet Fuel), the connection to the national electricity grid, with 97% renewable energy—as mentioned above—positively impacts the profitability of the investments required for green hydrogen and derivatives production (wind and solar photovoltaic plants supplemented with hydrogen storage). For these cases, the advantage of a grid connection could be reflected in a 5-10% decrease in the cost of hydrogen compared to an investment solely from off-grid wind and solar photovoltaic facilities with hydrogen storage.

4.2.3 - High water availability

Uruguay has access to the Atlantic Ocean and to a large number of rivers, some of them with basins that cover important areas of countries in the region. Among the rivers with basins in other countries, the following should be highlighted:

a) The Río Negro, with a basin of approximately 40% of Uruguay's area (70,714 km2; the basin covers areas of Brazil and Uruguay). The Río Negro flows into the Uruguay River.

b) The Uruguay River, with a basin twice the area of Uruguay (339,000 km2; the basin covers areas of Argentina, Brazil, and Uruguay). It flows into the Río de la Plata.

c) The Río de la Plata, with a basin 17 times the area of Uruguay (3,100,000 km2; it covers areas of Argentina, Bolivia, Brazil, Paraguay, and Uruguay).

Figure 4: Río de la Plata Basin.

Source: Adapted from cicplata.org.

The country has a significant rainfall system and water availability, with an average annual rainfall of 1,320 millimeters (see Figure 5). All this makes the existence of fresh water quite abundant and suitable for the production of green hydrogen.

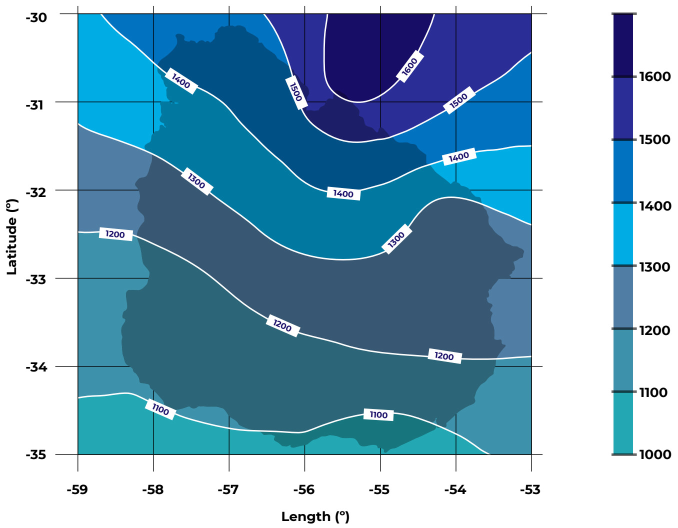


Figure 5: Average annual rainfall, Uruguay (1961-1990).

Source: Adapted from National Directorate of Meteorology.

The estimated hydrogen production for 2040, in this roadmap, is one million tons for different uses and derivatives. This would imply a consumption of 10 million m3 of water per year, taking into account that 9 to 10 kg of water are needed to produce 1 kg of hydrogen. Therefore, hydrogen production by 2040 would require a very low volume of water compared to current water uses in the country's agricultural and industrial sector[2].

4.2.4 - Biogenic CO_2 availability

For the production of synthetic fuels, such as e-methanol or e-Jet Fuel obtained from H2 and CO2, the country has biogenic CO2 availability, associated with industrial facilities that exploit biomass from sustainable production[3], close to areas with good availability of renewable resources.

Uruguay is very well positioned in terms of sustainable development certifications in its forestry production: reaching 80% in forest plantations and 100% for products with industrial processing in this sector (Uruguayan Forestry Producers Society, 2022). Based, among other aspects, on the development achieved by the forestry sector, and in particular by the industry associated with this productive chain, since 2016 bioenergy has become the leading energy source nationwide. Thus, it has relegated oil and its derivatives, the source that traditionally ranked first, to a second position (Ministry of Industry, Energy and Mining, 2021).

4.2.5 - Logistics

Uruguay has access to the Atlantic Ocean, allowing for the export of hydrogen and derivatives to Europe and the United States with shorter shipping distances than those of other countries with export potential. In this way, reduced transportation costs are achieved. The port of Montevideo offers a development opportunity for the export of hydrogen derivatives.

[2] As a reference, rice cultivation required a consumption of approximately 2 billion m3 of water per year, on average, in the years 2020 and 2021. This implies a water demand 200 times higher than that needed for hydrogen production by 2040 in this roadmap (Instituto Nacional de Investigación Agropecuaria, 2019; Ministerio de Ganadería, Agricultura y Pesca, 2021).

[3] As a result of a State policy that has been supported by all the political parties that have been in office since 1987 to date, Uruguay has promoted the development of forestry in a sustainable manner.

The country has no major geographical barriers and has access routes throughout the territory as well as infrastructure for the local transportation of hydrogen and its derivatives.

It should be noted that the Central Railway track will connect the area with the greatest potential for renewable energies with the port of Montevideo, providing very good opportunities for the transportation of hydrogen derivatives and facilitating their export possibilities. Likewise, the country has river and road transportation mechanisms that can help improve competitiveness in the transportation of export products.

As a precedent, it can be mentioned that in the energy sector, in the past decade, Uruguay faced and overcame multiple logistical challenges associated with the construction of generation infrastructure, large industrial plants and transmission works, among others. As an indicator, it can be noted that in 2014, 60% of the special cargo (either by dimension or weight) transported in the country was related to renewable energy projects.

Uruguayan countryside, natural grazing livestock and sustainable forestry

4.2.6 - A country to invest in

Uruguay is a country with a strong institutional framework and a profound sense of republicanism and rule of law. It ranks first in Latin America in terms of rule of law (World Justice Project, 2021) and full democracy (The Economist Intelligence Unit, 2021).

It is a country open to national and international private investment, with clear and stable rules, and is a reliable destination for doing business in one of the most economically attractive regions in the world. On the other hand, Uruguay has a good socio-political stability: it is ranked sixth in the world in terms of the civil and political liberties enjoyed by its people (Freedom House, 2022), and leads the region in terms of low perception of corruption (Transparency International, 2022).

At the same time, it has made considerable progress in the digitization of the public sector, ranking 26th in the e-Government Development Index and first in the region in 2020 (United Nations, e-Government Development Index, 2022). It has been awarded investment grade by the main international credit rating agencies (Standard & Poor's, Fitch Ratings, DBRS and Moody's) and has shown sustained growth in Gross Domestic Product (GDP) over the last few years, except for the drop in 2020, related to the covid-19 pandemic that affected the entire world.

Uruguay is among the world's leading economies for sustainable investment, according to JP Morgan's ESG Index. This takes into account the quality of governance and social and environmental factors. JP Morgan takes the Environmental, Social and Governance (ESG) factors to weight the country risk indicator. In this sense, Uruguay is among the most reliable emerging economies to invest in (see Figure 6).

Highest Performance in ESG Factors

Environment · **S**ocial · **G**overnance

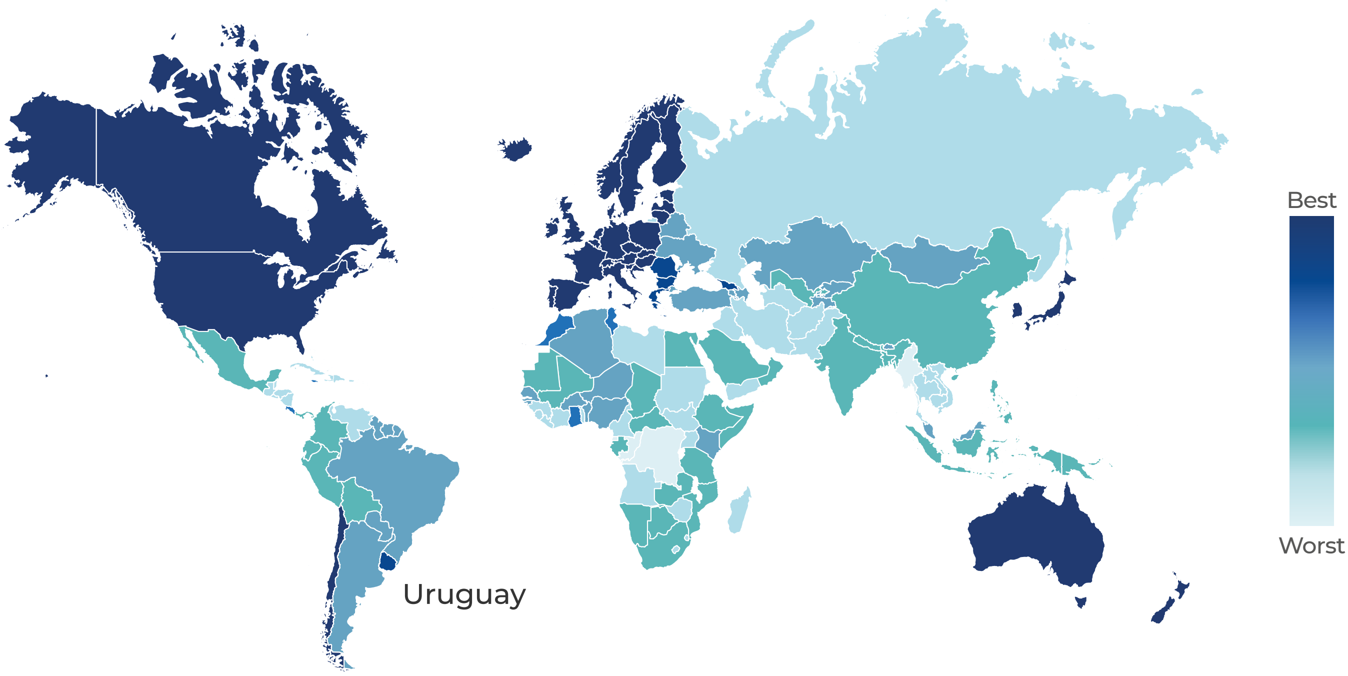


Figure 6: ESG factors performance map. Environment, Social and Governance. Year 2020.

Source: Uruguay XXI (JP Morgan Bluebay Asset Management - Verisk Maplecroft).

5. **Green Hydrogen** and Derivatives Production

5. GREEN HYDROGEN AND DERIVATIVES PRODUCTION

The costs of renewable energies mentioned above would allow Uruguay, by 2030, to reach green hydrogen production values (LCOH) between 1.2 and 1.4 USD/kgH2 in the west region and between 1.3 and 1.5 USD/kgH2 in the east region (see Figure 7), for a scale above 500 MW. These production costs would allow Uruguay to position itself competitively among net exporters such as Chile, Saudi Arabia, Oman, Namibia or Australia.

The alternative of producing hydrogen from offshore sources would imply a less competitive cost of 1.7 to 1.9 USD/kgH2 by 2030 (see Figure 7).

Estimates for a minimum daily production of 250 tons of H2 including energy and electrolysis (CAPEX, OPEX inc. water).
Storage, transport or transmission add 0.3 to 0.5 USD/KgH2.

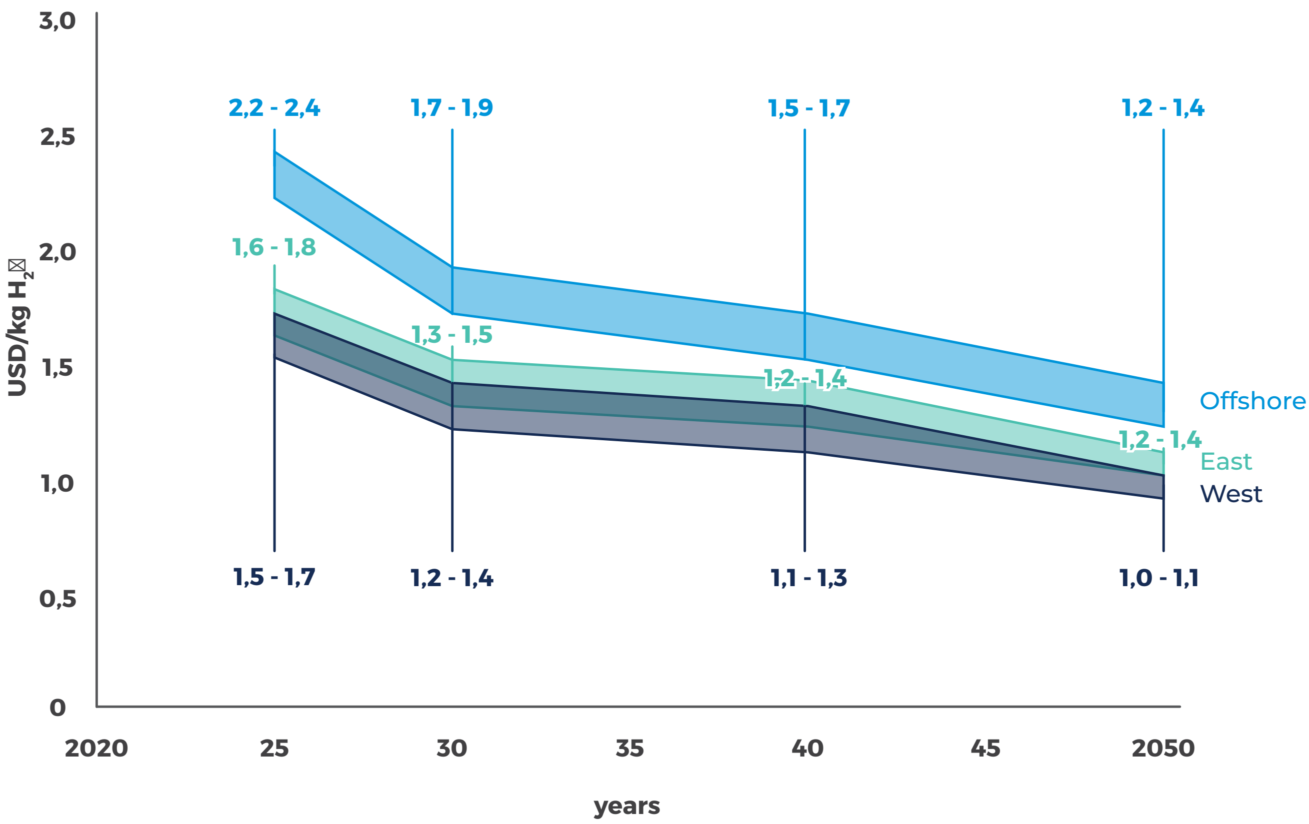
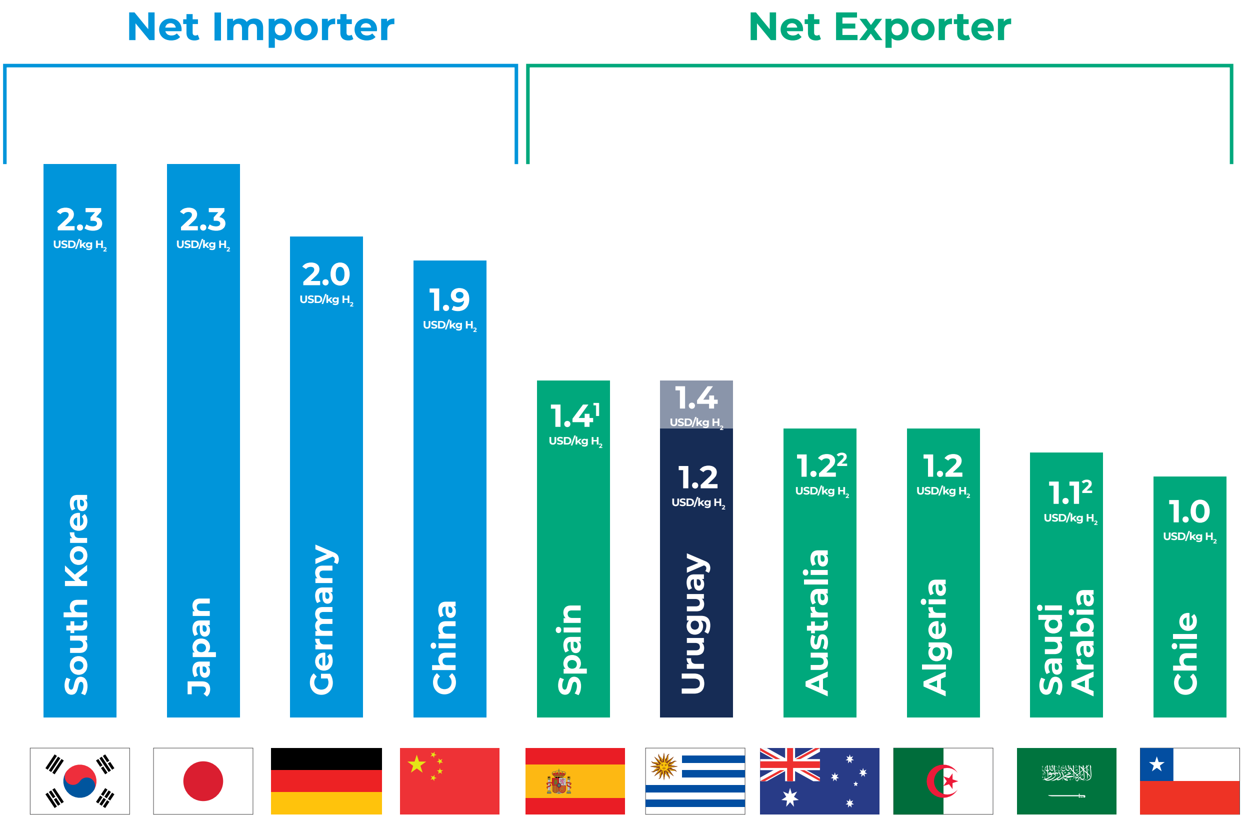


Figure 7a: Hydrogen production cost curve by region in Uruguay, USD/kgH2

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.



1. *Benchmark* taken from HyDeal ad for production costs at scale; excludes transportation and distribution costs.

2. *Benchmark* taken from Hydrogen Council projections; excludes transportation and distribution costs.

Figure 7b: Comparison of production costs 2030 (WACC: Chile 6%, Austria 5.4%, Saudi Arabia 5.3%, Spain 5%) (USD/kg H2)

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

In addition to hydrogen production costs, it is necessary to add logistics costs: these are transportation or electricity transmission and storage, depending on the configuration chosen, taking into account downstream hydrogen usage needs. For projects over 500 MW in scale, local transportation and storage of hydrogen by pipeline appears to be the most cost-effective option. This is achieved through the installation of electrolysis plants close to the renewable energy generation plants. The cost associated with local transportation and storage ranges from 0.3 to 0.5 USD/kgH2.

The development of the necessary infrastructure, implemented in a coordinated manner, would achieve synergies resulting in a 4% to 6% reduction of the levelized cost of hydrogen (LCOH). This takes into account the scenario that hydrogen pipelines, power transmission or port adaptations are made for several projects, rather than having each project build its own infrastructure.

Regarding the production of derivatives, by 2030, the production costs of green e-methanol and e-Jet Fuel could reach 465 USD/t and 1,205 USD/t respectively, considering industrial sources for biogenic CO2. The competitiveness of these products compared to those of fossil origin is linked to the taxation of CO2 in importing countries, as well as to the definition of quotas for green products in particular sectors, such as the shipping and aviation sectors.

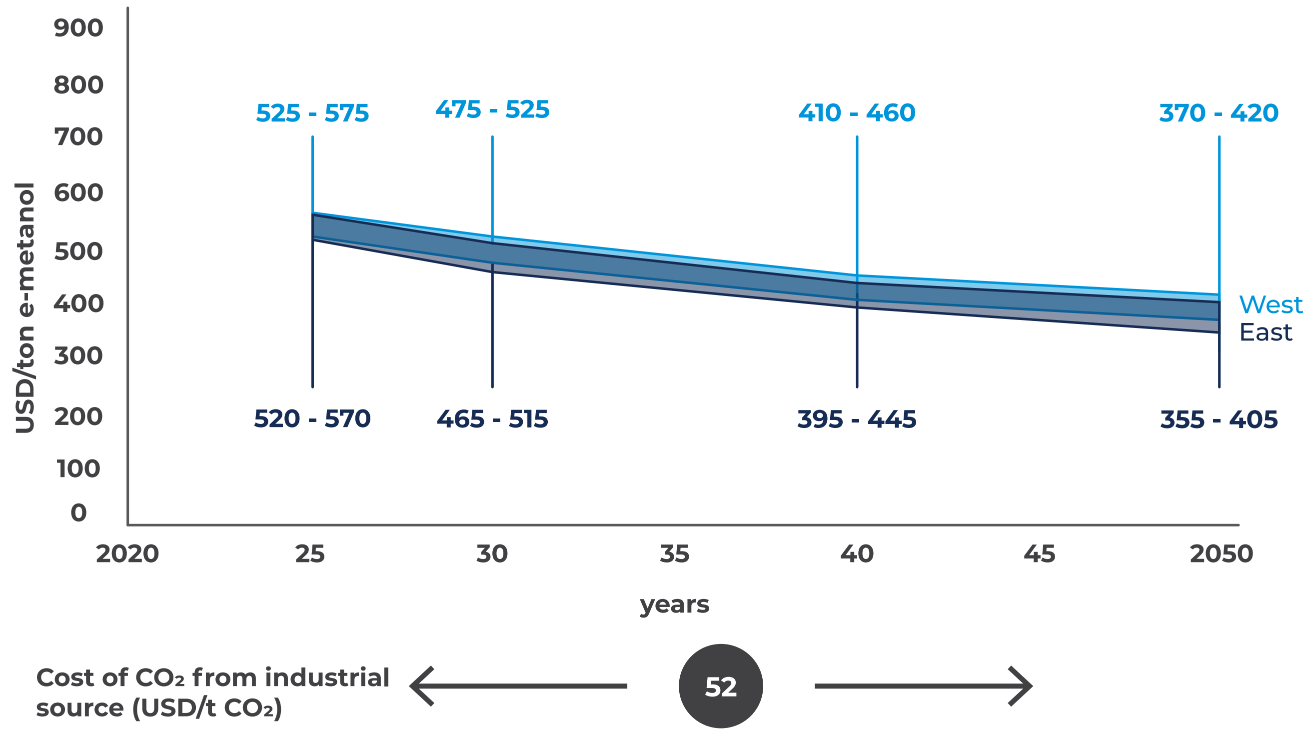


Figure 8a: CO2 supplied industrially: production cost curve for e-methanol (USD/ton e-methanol)

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

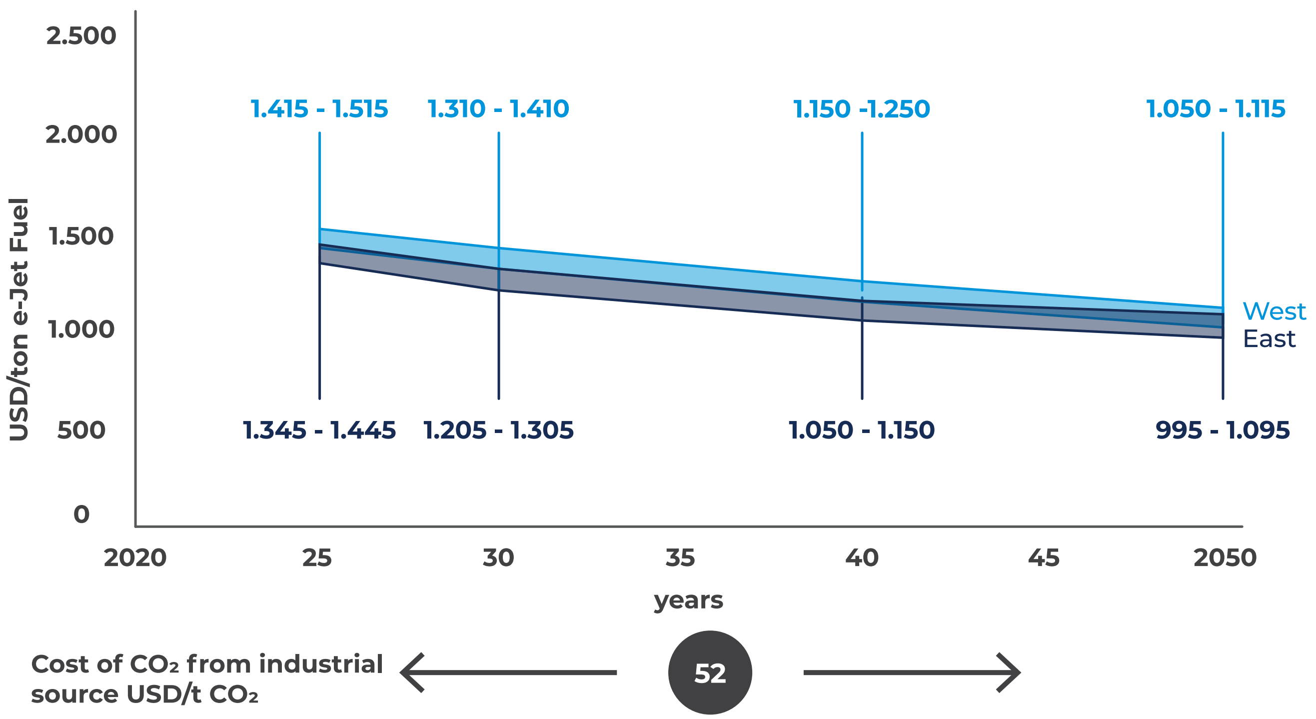


Figure 8b: CO2 supplied industrially: production cost curve for jet Fuel, (USD/ton jet fuel).

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

6. **Domestic** and **Export** Market Potential

6. DOMESTIC AND EXPORT MARKET POTENTIAL

Uruguay has a very good potential in the domestic market to decarbonize land and maritime transport as well as to substitute imports through the production of green fertilizers. This will be driven by an export market where the country stands out for its competitiveness in producing green synthetic fuels that will lower emissions in the shipping and aviation industry.

6.1- Domestic market

It is identified that the main domestic opportunities for hydrogen development in Uruguay will be driven by cost-competitive applications compared to fossil alternatives or other low-emission applications (e.g., the development of intensive heavy-duty vehicles), by applications affected by decarbonization objectives of various industry sectors (such as the shipping and aviation sectors) and, finally, by applications affected by local regulations and/or incentives (e.g., the promotion of the use of green fertilizers).

The following aspects are taken into account to determine the main internal demand goals for the different potential uses:

Transport

The break-even point of Total Cost of Ownership (TCO) for road transport with fuel cells compared to fossil fuel and batteries will be reached approximately by 2026 for heavy-duty trucks. It is estimated that the heavy transport fleet for the year 2030 will be around 21,700 vehicles and by 2040 it will reach approximately 23,300 vehicles. The most optimistic scenario assumes a penetration of fuel cell electric vehicles (FCEVs) in heavy transport of approximately 30% (6,500 vehicles) by 2030 and 75% (17,500 vehicles) by 2040.

Maritime transport

Taking into account the announcements of international players and decarbonization targets of the International Maritime Organization (IMO), the demand for maritime transport fuels, such as green ammonia or e-methanol, is projected to grow. A penetration of 1% for domestic market container vessels by 2030 and 9% by 2040 is assumed.

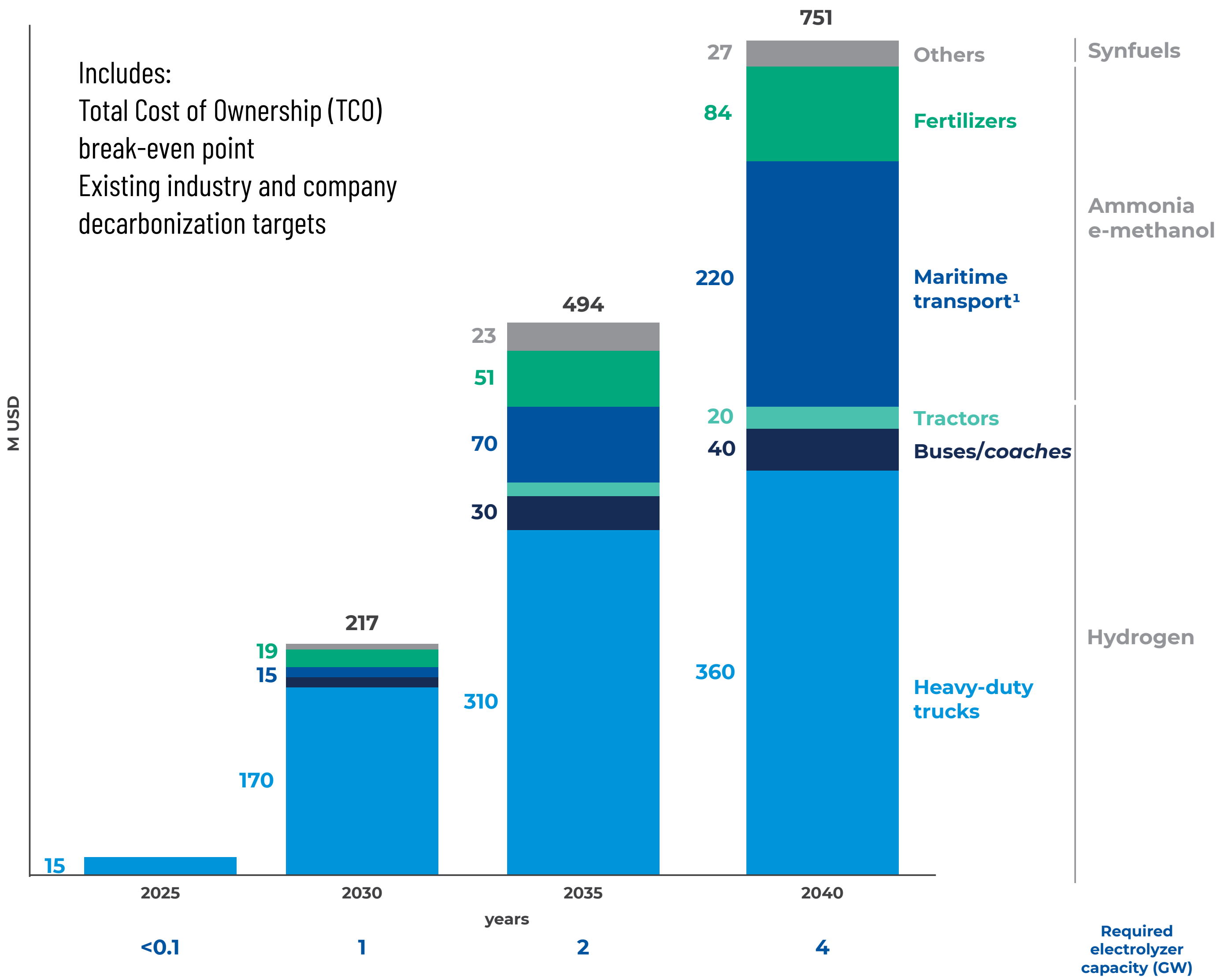
Fertilizers

For the estimation of the green fertilizer market, a replacement of 20% of urea imports by 2030 and 80% by 2040 is taken into account.

Port of Buceo, Montevideo

In a reference scenario, and considering the proposed goals, the domestic opportunity would reach a turnover of approximately 200 million dollars in 2030 and would be in the range of 750 million dollars in 2040. By 2030, the opportunity will be 85% driven by land transportation applications (e.g., 40-ton trucks with fuel cell technology), the first ones to be cost-competitive.

By 2040, the adoption of land transportation applications would grow to an annual turnover of 420 million dollars. Also, the demand for green ammonia or e-methanol for the shipping sector, as well as for green fertilizers, would increase, which could replace imports, thereby representing an additional turnover opportunity of more than 300 million dollars.



[1] Considers consumption for international routes

Figure 9: Total domestic demand (includes high and medium heat, airlines [aircraft fuel], medium duty trucks, forklifts, and gas blending), M USD

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

6.2- Export market

Import needs by the main demand centers could be concentrated in five products. On the one hand, there is hydrogen, driven by demand in land transport applications, as an input for industry (e.g., steel and refineries), as well as for electric power and heat generation. The demand from the shipping sector to achieve decarbonization targets is driving the production of e-methanol and ammonia (NH3), the latter as the main input for green fertilizers. In addition, e-Jet Fuel will play an important role, driven by aviation sector regulations regarding the incorporation of Sustainable Aviation Fuel (SAF). Finally, there is Direct Reduced Iron (DRI), due to the growing demand for green steel in the world, where hydrogen is one of the main inputs.

For Uruguay, the size of the opportunity for green hydrogen and related products exports to the European and US markets will depend on their relative competitiveness vis-à-vis potentially competing countries and regions such as the Middle East, Brazil, Chile and North Africa. This competitiveness may vary according to products and destinations:

For hydrogen

Uruguay's landed costs (United States and Europe) are in line with those of its main competitors. Transportation costs would have a lower impact on landed costs, and could offset differences in production costs between countries. The competitiveness of exports to Europe would be affected (as for all the other countries that make up the group of net exporters), if a physical interconnection via gas pipeline from North Africa were to be implemented so that hydrogen could arrive from countries in that region.

For e-methanol and e-Jet Fuel

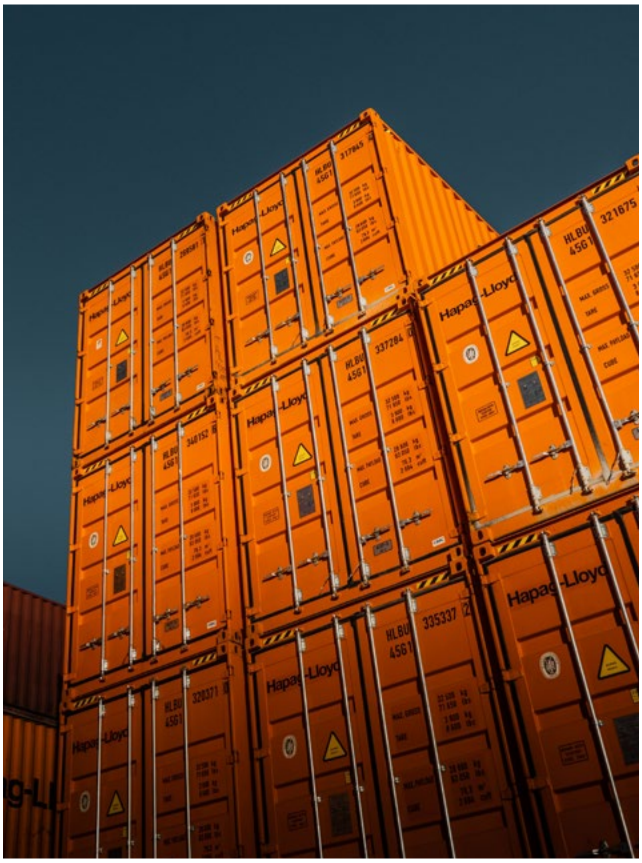
Uruguay would have landed costs in line with its main competitors, thanks to the complementarity between its renewable resources, the use of a decarbonized grid and access to biogenic CO2 obtained from industrial and/or energy processes based on sustainable biomass.

For green ammonia

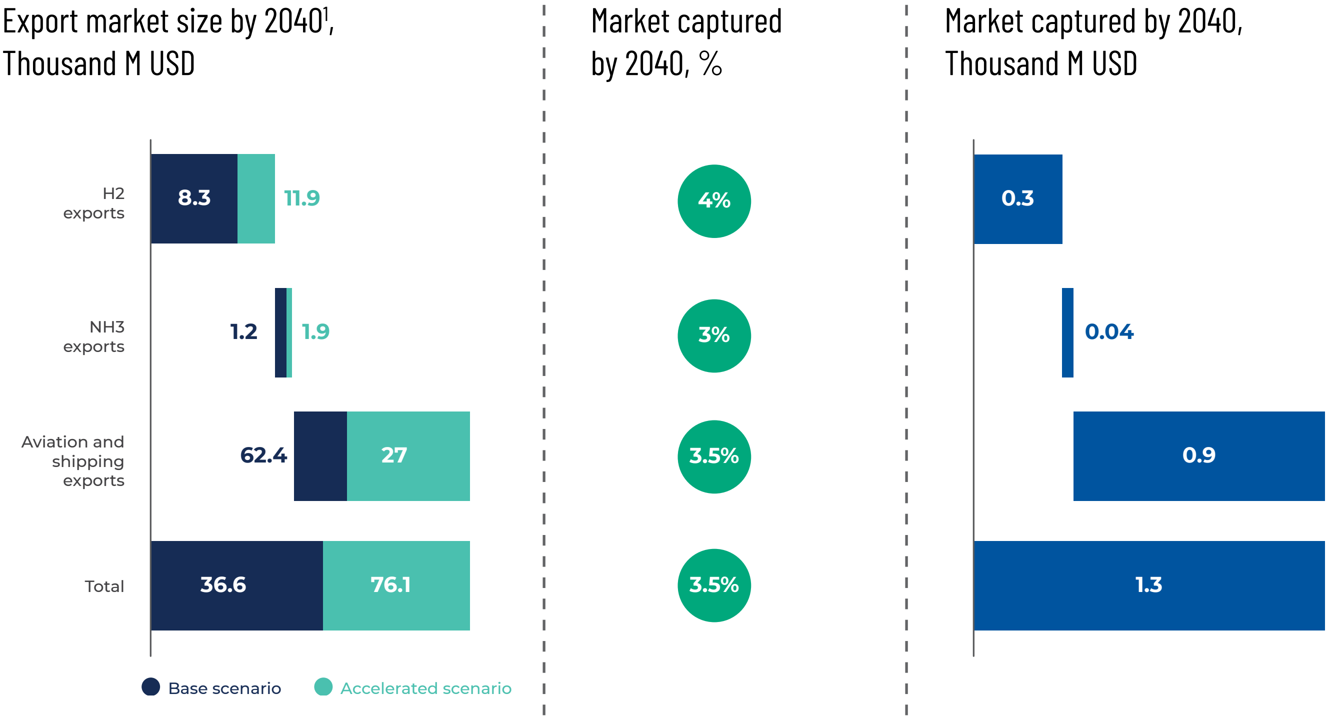
A product on which transportation costs have a limited impact, Uruguay would be less competitive than those mentioned above, and would face greater challenges for its development.

For DRI

Uruguay's production costs are in line with those of its main competitors. Given the low global availability of high-quality iron, it would have a competitive advantage by having it available. Its processing would require significant amounts of green hydrogen.



According to the competitiveness levels analyzed and considering a more conservative scenario (base scenario) regarding the projected global market volume for each product, a target market capture target of 3.5% could be set (see Figure 10).



[1]US and UE for synthetic fuels for aviation and shipping, H_2 y NH_3

Figure 10: Proposed export market capture for the roadmap.

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

This means that Uruguay would have an export opportunity of approximately 1.3 billion dollars by 2040, and 95 million dollars by 2030.

The e-Jet Fuel would account for 55% of this opportunity by 2040, while hydrogen would account for 25% and the shipping sector (ammonia or e-methanol) for 15% (see Figure 12).

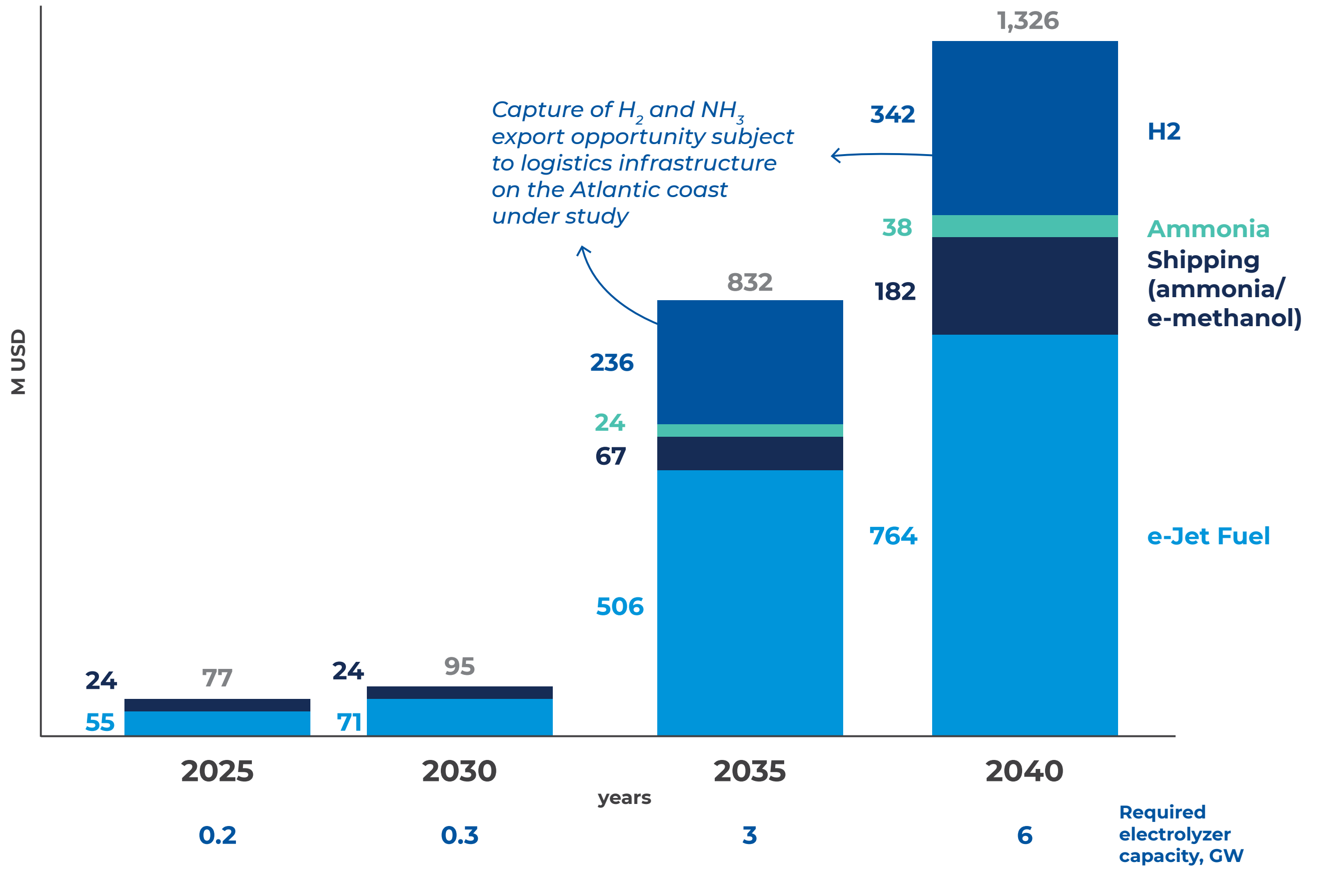


Figure 12: Export opportunity (M USD) to the US and Europe by application

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

The exploitation of iron reserves for their transformation into DRI (with the use of green hydrogen) represents an additional export opportunity for Uruguay, taking into account the availability of high quality iron ore in the country (concentration level above 67%). This would represent an additional annual turnover of up to 4.1 billion dollars by 2040. For this purpose, an additional 5-6 GW of electrolyzer capacity and an additional 10-12 GW of electric power generation will be needed from 2035 onwards. This opportunity requires the development of port infrastructure in the east coast of the country and further analysis, so it is not included as a target in this roadmap. However, it may be incorporated later, after the hydrogen-related markets have further matured.

7.

Ambition 2040

7. AMBITION 2040

Based on the competitive advantages presented, Uruguay has very good conditions to promote the development of green hydrogen and derivatives projects. This development could be a key element to continue boosting both economic and sustainable growth.

The proposed roadmap aims to take advantage of these opportunities, given the country's capacities, the size and growth momentum of export markets for H2 and its derivatives, the existing infrastructure.

These capacities are planned to be developed in three phases:

Phase 1

From 2022 to 2024, the aim will be to boost the development of the domestic market and lay the groundwork for the first export projects. Progress will be made in the implementation of the sector-specific regulations that will be required as the industry develops; in the engineering necessary for infrastructure works; and in the implementation of incentives for the first projects and for the subsequent stage. In this phase, it would be necessary to focus on the implementation of demonstration projects, targeting the most relevant applications for the domestic market (e.g., land transportation) and on attracting the first larger-scale initiatives, focusing on the export market. Mechanisms will be promoted to develop research and innovation based on the Hydrogen Sector Fund launched in 2022. Within this framework, the elaboration of the first pilot projects for the production and use of green hydrogen and its derivatives will be promoted, as well as research in this area. At this stage, the study of hydrogen production potential based on offshore wind power will begin, as an input for phases 2 and 3.

Phase 2

From 2025 to 2029, it will aim at scaling up the domestic market (demand and projects), as well as having the first export-scale projects (such as e-methanol) in operation. To this end, developing the necessary support infrastructure (e.g., pipelines and transmission lines), implementing incentives focused on attracting investment, improving cost competitiveness, and stimulating domestic demand are of key importance.

Phase 3

During Phase 3, starting in 2030, the aim for the year 2040 should be confirmed. The development of the domestic market will be consolidated in this phase. The prior definition of logistics or port infrastructure needs, or offshore production on the Atlantic coast, may allow further development of the hydrogen value chain and its derivatives. Scaling up towards the production and export of products such as green hydrogen and green ammonia will be possible.

Roadmap phases	Phase 1 (2022 - 2025): Develop regulation; develop first pilot projects; attract first export-scale projects.	Phase 2 (2026 - 2030): Domestic expansion; start of the first export-scale projects.	Phase 3 (+2030): Large-scale domestic market; accelerated growth of exports.
Project overview	+1-2 small-scale projects implemented, larger-scale projects under development.	+3-4 medium-scale projects (100-200 MW) and +1-2 scaled projects.	+ medium-scale projects (100-200 MW) and + larger-scale projects.
Production (energy and hydrogen production)	• 200-500 MW of RES power capacity under development. • ~50 MW of H_2 production capacity for small scale and 100-300 MW under development.	• 2-4 GW of RES feed-in capacity. • 1-2 GW of H_2 production capacity.	• ~20 GW of RES capacity. • ~10 GW of H_2 and derivatives production capacity.
Demand (end uses in mobility, industry, and energy)	• +1-2 small-scale projects implemented for transportation uses (heavy trucks, long-distance buses, agricultural vehicles). • +1 project under development in synfuels (incl. methanol).	• ~1-2 scaled projects under development for synfuels. • +domestic transport projects; H_2 derivatives projects for maritime transport or fertilizers.	• ~3-4 scaled projects under development for synfuel, H_2 and NH_3 exports. • More domestic projects throughout sectors (e.g., transportation, shipping, fertilizers, etc.).
Infrastructure and logistics (pipelines, storage, ports)	• Plan and develop detailed engineering for pipelines, transmission lines and ports. • Develop port solution for synfuels export in Montevideo.	• Plan and develop detailed engineering for Atlantic export ports. • Implement infrastructure plan (i.e., pipelines and transmission lines) and orchestrate coordinated deployment to capture synergies.	• Build logistics solution for export by coastal zone in the East. • Continue orchestrated coordination of infrastructure deployment to capture synergies.
Key mechanisms required: 1 Regulation. 2 Incentives. 3 Bilateral agreements. 4 Social license. 5 Talent.	1 Develop safety and technical standards and expedited permit processes. 2 Design incentive structure for Phase 2, provide financial and coordination support for pilots. 3 Establish bilateral agreements to promote the deployment of pilots and R&D development. 4 Launch hydrogen roadmap with clear signal to the transportation and synfuels sector. 4 Create national awareness and branding around the potential of the green hydrogen and derivatives industry. 5 Coordinate and design talent development programs with the private sector and academia.	1 Land area for infrastructure deployment in Phase 3. 2 Establish incentives focused on investment attraction, cost competitiveness and stimulation of domestic demand. 2 Ensure coordination along the value chain and support for project development at scale. 4 Create national awareness and branding around the potential of the green hydrogen and derivatives industry. 5 Implement talent development programs with the private sector and academia.	2 Consider additional incentives for specific domestic applications (e.g., synfuels blending quota) and to attract foreign investment.

Figure 12: Phases and activities of the H2 sector roadmap in Uruguay..

Source: (McKinsey & Company, 2021) in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

The domestic market and exports of green hydrogen and derivatives represent an annual turnover opportunity[4] of 300 million dollars per year by 2030 and 2.1 billion dollars for Uruguay by 2040 (see Figure 13).

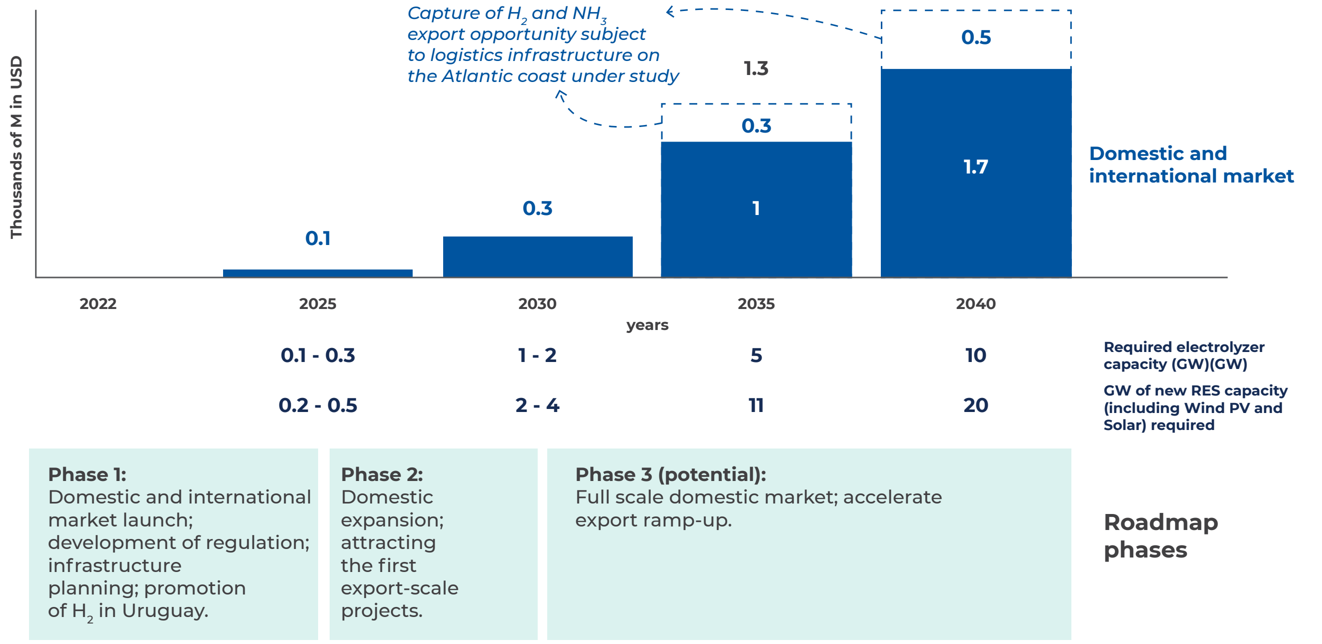


Figure 13: Targets and projections of the Uruguayan hydrogen and derivatives market: 2025-2040.

Source: McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB

[4] Not including the DRI opportunity

These phases and associated goals can be seen in the following growth schedule:

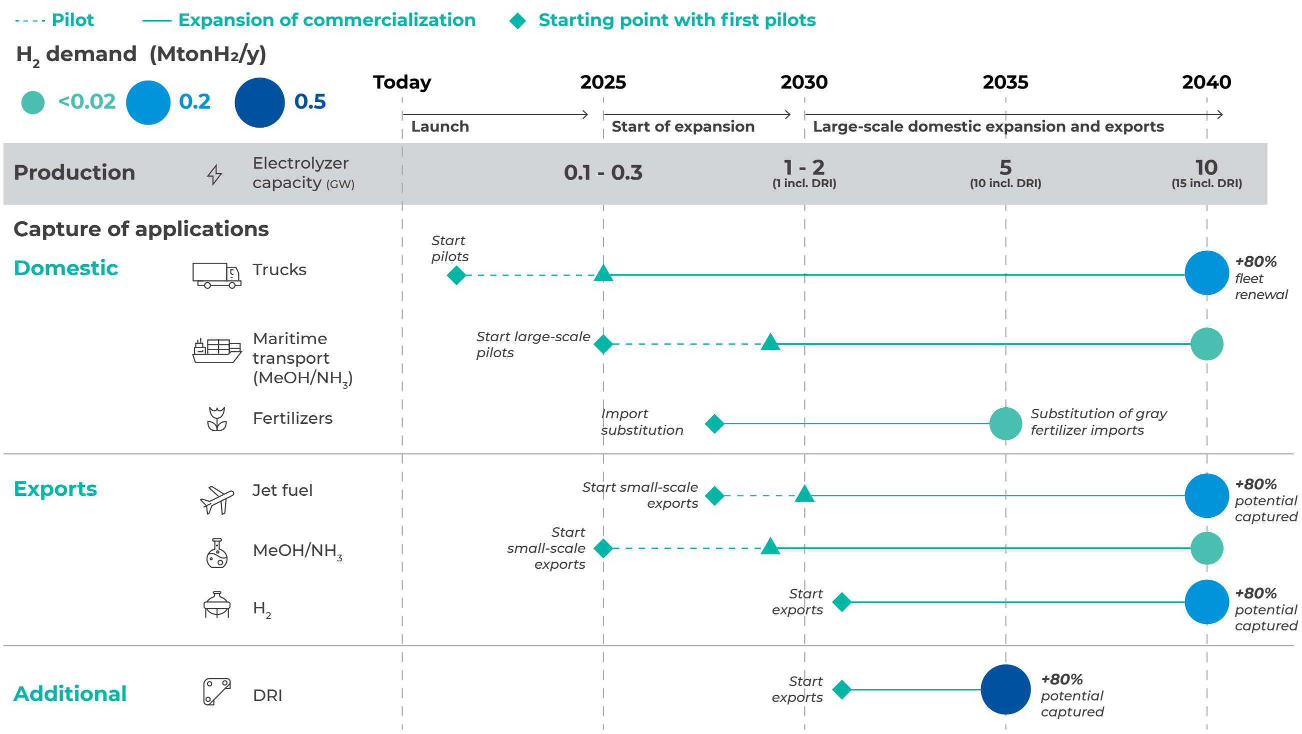


Figure 14: Development schedule.

Source: Adapted from McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

Capturing the aforementioned opportunity of 2.1 billion dollars per year implies relevant socioeconomic impacts for Uruguay. In economic terms, the annual turnover of this industry will be about 2% of the projected GDP, will generate more than 34,000 direct jobs and will avoid 7 $MtCO_2$ of emissions by 2040 (see Figure 15).

Goal	Indicator	2030	2040
Lay the basis for country's long-term growth	Annual turnover in thousands of M USD	0.3	2
	Potential turnover over projected future GDP	+0.5%	+2%
Create +34K skilled jobs: qualified technicians, operators and engineers	Jobs created in thousands	+6	+34
	Total accumulated investment in thousands of M USD	2.5	19
Eliminate the equivalent of Uruguay's net emissions by 2040	$MtonC0_2$ annual emissions reduced	0.6	7

Fig. 15: Socioeconomic and environmental impact of green hydrogen sector development in Uruguay (not including DRI opportunity)..

Source: Adapted from McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

This opportunity will diversify the country's productive matrix by increasing the value added through the incorporation of a new industrial chain link. It will help diversify Uruguay's export offer, opening up possibilities to new markets worldwide. Likewise, dependence on imported fossil fuels will be reduced and Uruguay's position as a sustainable country will be strengthened.

8.

Identification of Risks for Sector Development

8. IDENTIFICATION OF RISKS FOR SECTOR DEVELOPMENT

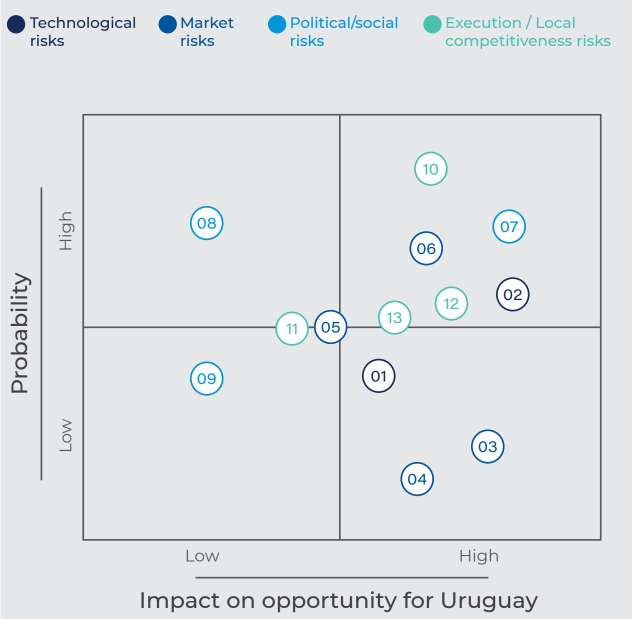
Some elements that should be considered and duly addressed were identified, so as not to hinder the development of the green hydrogen industry. Thirteen (13) main risks have been identified and grouped into four categories.

Risk	Key Evaluation Metrics
Technological Risks	
01 Costs of electrolyzers and renewables are decreasing more slowly than expected.	Prices of electrolyzers and renewables from manufacturers.
02 Innovative/alternative technologies (e.g., electric batteries) emerge.	Technology reports from international public forums.
Market Risks	
03 Slower than expected adoption of decarbonized/green hydrogen products by industry and countries.	Regulatory and industry/compliance announcements for target markets.
04 Lower than expected carbon taxes in the US and EU.	Oil and natural gas prices and projections.
05 Lower oil/natural gas prices.	H_2-related projects / production capacity announcements by region.
06 Increased local production capacity in key markets or competitors.	
Political / Social Risks	
07 Low acceptance of logistics infrastructure in the eastern zone.	Delays vs. implementation plan.
08 Low acceptance of H_2 and NH_3 proximity in urban areas.	Public opinion surveys.
09 Limited application of demand-based incentives (e.g., carbon tax, mandates).	
Execution / Local Competitiveness Risks	
10 Higher than expected country risk for investments.	Country risk premium.
11 Lower than expected competitiveness of renewables (capacity factors, complementarity).	Operational indicators (capacity, utilization, and cost factors) of pilots.
12 Slower than expected infrastructure execution.	Fuel cell vehicle penetration/share.
13 Slower development of the domestic transportation ecosystem.	

Fig. 16: Identification of 13 risks grouped into four aspects: technological, market, political-social and execution/competitiveness.

Source: Adapted from McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

Six risks with the highest probability of occurrence and impact at the national level are presented below, and mitigation strategies are proposed:



02	*Innovative/alternative technologies emerge.*	**· Monitor the evolution of the main competitive technologies (e.g., battery costs).**
06	*Increased local production capacity in key markets or competitors.*	**· Establish early supply and demand relationships for the long term.**
07	*Low acceptance of logistics infrastructure construction in the east.*	**· Create national awareness and branding around the potential of the green hydrogen industry. · Execute early participation process.**
10	*Higher than expected country risk for investments.*	**· Ensure an expedite and transparent permitting process. · Create national awareness and branding around the potential of the green hydrogen industry.**
12	*Slower than expected infrastructure execution.*	**· Ensure an infrastructure development plan, including process turnaround times. · Establish a project management unit for process control.**
13	*Slower development of the domestic transportation ecosystem.*	**· Ensure coordination along the value chain. · Develop incentives on cost competitiveness and demand.**

Figure 17: Mitigation strategies for the main six risks identified, according to their probability and impact.
Source: Adapted from McKinsey & Company, 2021, in accordance with contract #: C-RG-T3777-P001 concluded with the IADB.

The market and industry evolution linked to the development of green hydrogen are very dynamic and may impact some projects. It is necessary to create monitoring processes on the evolution of technologies and their costs.

Another risk identified is related to the positioning of new competitors in key markets, which put pressure on the supply side. In this sense, it is essential to establish early supply and demand relationships for the long term. In addition, one aspect that could have an impact on the industry's development is the difficulty of generating the necessary infrastructure in a timely manner. Progress will be made in the analysis and proposal of an infrastructure development plan, in coordination with the different actors from the political sector.

With regard to social barriers that may be faced, it is worth raising national awareness about the potential of the hydrogen industry and the benefits that it would bring to Uruguayan society in different areas. There will also be instances for early participation of the different relevant actors. As a cross-cutting aspect to those mentioned in previous paragraphs, efforts will be made to ensure good coordination along the entire value chain.


Salto Grande Dam, Salto

9. Building a **State Policy**

9. BUILDING A STATE POLICY

To boost the green hydrogen economy at the national level, it is necessary to plan for the long term and move forward with specific actions today. It will be necessary to develop regulations and incentives, analyze logistical aspects, create capacities and promote citizen participation. The H2U Program will seek to implement the actions proposed in this document in coordination with different government institutions, the private sector, academia and civil society.

9.1 - Development of regulatory zspects and incentives

The country, based on the experience gained in the process of incorporating renewable energies and other large-scale projects, will develop capacities and mechanisms to optimize the permits and authorization requirements which are required for the development of projects related to green hydrogen and its derivatives. Emphasis will be placed on key issues for the development of green hydrogen and derivatives, both for local consumption and for export, in particular those related to the design of green hydrogen certification, the creation of incentives, tax treatment and other mechanisms. Specific incentives are already in place within the framework of Law No. 16,906 on Investment and Industrial Promotion as well as tariff exemptions for the purchase of fuel cell vehicles.

During 2022, it is worth highlighting the creation of the Green Hydrogen Sector Fund, an initiative of the MIEM together with LATU and ANII. Within the framework of this Fund, aimed at fostering innovation and research in green hydrogen at the national level, a first line of action has been promoted to finance the implementation of the first production projects. 10 million dollars have been earmarked and will be granted through an open call for proposals aimed at the private sector.

In line with the powers granted to the Energy and Water Services Regulatory Unit (URSEA), under Article 150 of the Accountability Law No. 19,996 of 2021, the regulation regarding the production, storage and transportation of hydrogen will be issued. In this way, clear technical and safety standards will be established for this energy vector and its derivatives.

On the other hand, progress will be made in aspects related to streamlining the management of electric transmission and gas pipeline easements. It will be necessary to evaluate attractive schemes in terms of tolls for the use of energy distribution networks, as well as for the use of the electricity grid (taking into account the potential of its high renewable energy share). The development of H2-related infrastructure implies the decentralization of activities of an industrial nature in rural areas, which may involve the re-categorization of soils.

As progress is made, the existing barriers and the need to promote new incentives or restrictions will be identified and adjusted to the opportunities and challenges of the sector.

9.2 - Promotion of citizen participation and capacity building

Transparent and active communication with the public will be promoted, using existing mechanisms at the national level, in order to create ownership of the concept of sustainability and the country's positioning at the global level. In addition, efforts will be made to develop content and forms of communication that allow for a better understanding of the technology and its benefits, as well as of the contribution to the global challenges of decarbonization. People should be kept informed of the progress being made, with special attention to those actors particularly involved in each case.

Local capacity building is a key element to enhance the development of green hydrogen and avoid possible gaps between supply and demand in terms of staff for operational, technical and engineering areas. Training in renewable energies, and in particular in hydrogen-related technologies, should be strengthened. The greatest needs related to existing and potentially required local capacities are identified in those aspects related to electrolyzers and the production of derivatives; in this case, further training of experts in this area is particularly necessary.

Gender aspects will be taken into account in order to provide equal opportunities and reduce possible existing gaps.

Professional training and specialization will be enhanced towards tertiary education focused on hydrogen and its derivatives. In coordination with the National Council for Innovation, Science and Technology (CONICYT), a program will be developed to generate scientific and technical capabilities.

9.3 - Support for infrastructure development

Uruguay has the infrastructure already in place for green hydrogen and derivatives projects to start operating. In this sense, the port of Montevideo has the opportunity to develop the export of synthetic fuels at an early stage. On the other hand, the Central Railway track connects the area with the greatest potential for renewable energies with the port of Montevideo, providing very good opportunities for the transportation of hydrogen derivatives and facilitating their export possibilities. For local transportation, there are waterways and roads with access to the entire country that also connect to the capital's port.

Part of the infrastructure to be developed involves the installation of new electricity transmission networks, gas pipelines and eventually port works. These aspects will be evaluated and coordinated with the different actors involved in the sector in order to define the different steps to be taken.

The implementation of a new export port with greater ship draft depth or the search for other offshore logistics solutions will be analyzed in the first roadmap development phase, with the aim of evaluating the most convenient way to capture the hydrogen, ammonia and eventually DRI export opportunity in the long term.

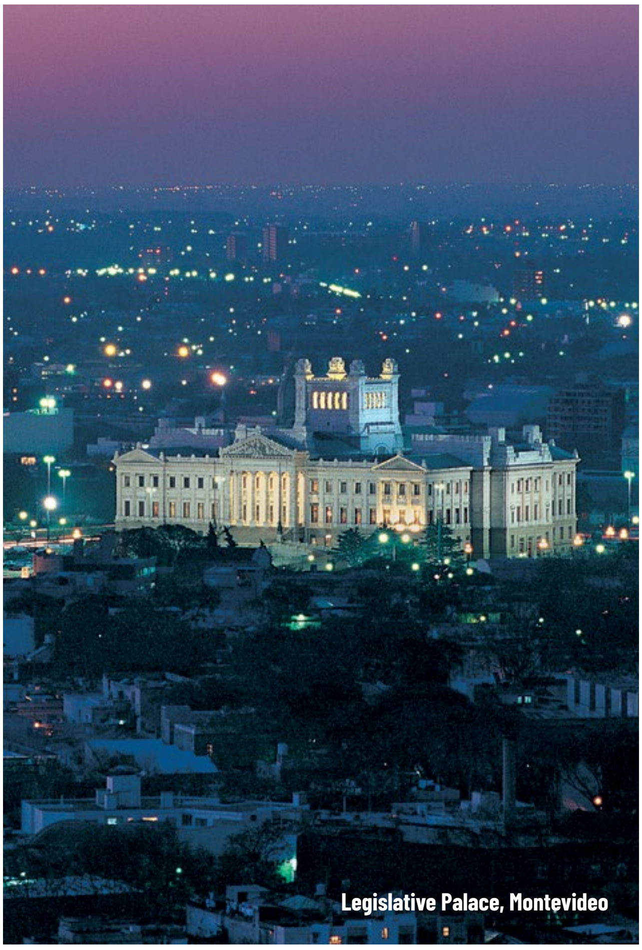
Ways of collaboration with countries in the region will be analyzed to make the export of hydrogen and derivatives produced in their territories feasible, through the use of local infrastructure, particularly existing rivers and ports.

Offshore hydrogen production is currently under development by several companies globally. Given the potential of wind energy in the Atlantic, and with a long-term view, the potential of this resource in the maritime platform will be studied, articulating actions together with ANCAP.

9.4 -Strengthening international cooperation

The promotion of hydrogen, both domestically and for export, requires greater coordination and cooperation between countries. On the one hand, the alliance with those countries with import needs (European Union, United Kingdom, Japan and Korea, among others) will be necessary to accelerate the hydrogen economy development process. These countries can provide support in regulatory aspects and talent generation, as well as in facilitating initial investments.

On the other hand, it is important to seek regional cooperation to promote synergies between countries and harmonize the requirements that may arise at international level. Some countries have already presented their roadmaps, such as Chile and Colombia, and others are moving forward with projects, such as Costa Rica, Argentina, and Brazil.



Legislative Palace, Montevideo

9.5 - Roadmap implementation: H2U Program

To promote the proposed roadmap, the country is developing the H2U Program, which aims at generating governance and monitoring the implementation of the suggestions included in this document.

The program will have the following components that will be articulated with public and private organizations, academia, and civil society:

Component	Responsible parties and possible partnerships	Activities
INNOVATION	MIEM, ANII, LATU, academic sector, CONYCIT	· Hydrogen Sector Fund, call for State-supported projects and research and innovation projects.
INVESTMENT	MIEM, MEF, MA, MRREE, OPP, Uruguay XXI	· Tax incentives, support in the management of permits and international positioning.
INFRASTRUCTURE	MIEM, MTOP, ANP, ANCAP, UTE	· Port aspects, electricity transmission networks, gas pipelines, use of railroads.
REGULATION	MIEM, URSEA, MVOT, MTOP, MA	· Quality and storage regulations. Safety aspects. · Aspects related to the national electricity system. · Guidelines for land use and easements for gas pipelines and electricity transmission.
OFFSHORE	MIEM, ANCAP	· Competitive process for prospecting and evaluating green hydrogen production for eventual future development.
COMMUNICATION AND CAPACITY BUILDING	MIEM, national academia: universities, UTU, CONYCIT, among others. MRREE and AUCI. Civil society.	· Design and implementation of a national communication plan for decarbonization and H2 aspects. · Professional and technical training. · Alliances with international cooperation for capacity building and international communication aspects.

10.

References

10. REFERENCES

Airbus. (2022). ZEROe Towards the world's first zero-emission commercial aircraft. Retrieved from http://www.airbus.com/en/innovation/zero-emission/hydrogen/zeroe.

Banco Interamericano de Desarrollo. (2021). Hidrógeno Verde: un paso natural para Uruguay hacia la descarbonización. Montevideo.

Boeing. (2022). Boeing Buys Two Million Gallons of Sustainable Aviation Fuel for its Commercial Operations. Retrieved from https://boeing.mediaroom.com/2022-02-07-Boeing-Buys-Two-Million-Gallons-of-Sustainable-Aviation-Fuel-for-its-Commercial-Operations.

British Petroleum. (2022). BP sets ambition for net zero by 2050, fundamentally changing organisation to deliver. Retrieved from http://www.bp.com/en/global/corporate/news-and-insights/press-releases/bernard- looney-announces-new-ambition-for-bp.html.l.

European Commission – Climate Action. (2022). European Climate Law. Retrieved from https://ec.europa.eu/ clima/eu-action/european-green-deal/european-climate-law_en.

Freedom House. (2022). Expansión de la libertad y la democracia. Retrieved from https://freedomhouse.org.

General Motors. (2022). Reducing Carbon Emissions. Retrieved from https://www.gmsustainability.com/ priorities/reducing-carbon-emissions.

Instituto Nacional de Investigación Agropecuaria. (2019). Manejo del Riego y Productividad del Agua en el cultivo de arroz en el Uruguay. Serie técnica INIA Arroz, 49-52.

International Renewable Energy Agency. (2020). Green Hydrogen: A guide to policy making. Abu Dhabi..

IPCC. (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of clim. In press.

Maersk. (2022). A.P. Moller - Maersk accelerates fleet decarbonisation with 8 large ocean-going vessels to operate on carbon neutral methanol. Retrieved from http://www.maersk.com/news/articles/2021/08/24/ maersk-accelerates-fleet-decarbonisation.

McKinsey & Company. (2021). Insumos para la Hoja de Ruta de Hidrógeno Verde del Uruguay. Montevideo: Banco Interamericano de Desarrollo.

McKinsey & Company. (2022). The net-zero transition: What it would cost, what it could bring by McKinsey. McKinsey & Company.

Ministerio de Ambiente Uruguay. (2021). Estrategia Climática de Largo Plazo, 2021 Uruguay. Montevideo.

Ministerio de Ganaderia, Agricultura y Pesca. (2021). Encuesta de arroz, zafra 2020-2021. Montevideo: Serie encuestas N.° 367.

Ministerio de Industria, Energía y Minería Uruguay. (2021). Balance Energético Nacional. Montevideo.

Presidencia de la República, Uruguay. (2021). Objetivo de Desarrollo Sostenible, Informe Nacional Voluntario 2021. Montevideo.

Renewables - REN 21. (2021). Renewables 2021 Global Status Report. Paris.

Shell. (2022). Our climate goals. Retrieved from http://www.shell.com/energy-and-innovation/the-energy-future/ our-climate-target.html#iframe=L3dlYmFwcHMvY2xpbWF0ZV9hbWJpdGlvbi8.

Sociedad de Productores Forestales del Uruguay. (2022). Uruguay tiene un 100% de su producción forestal sostenible. Retrieved from https://www.spf.com.uy/category/pefc.

Transparencia Internacional. (2022). Country Data. Retrieved from https://www.transparency.org.

Unidad de Inteligencia de The Economist. (2021). Índice de Democracia. The Economist Intelligence Unit. Londres.

World Energy Council 2021. (2021). Decarbonised hydrogen imports into the European Union: challenges and opportunities. Virtual event.

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