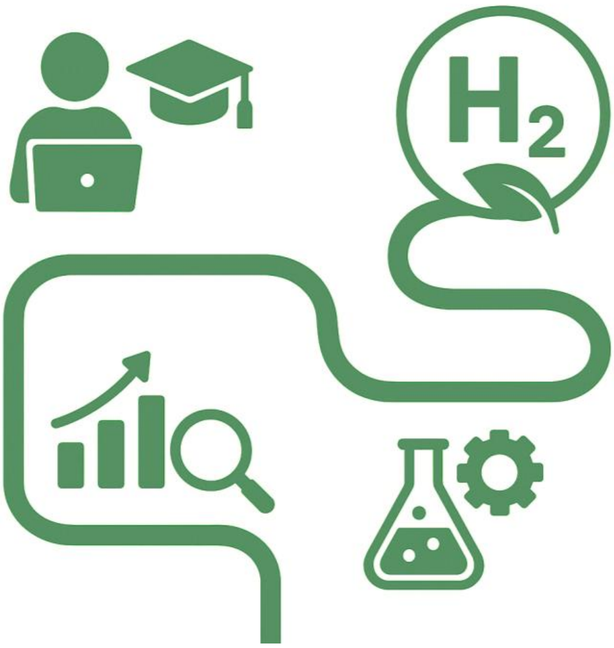
HyUruguay:

Development of a Green Hydrogen R&D Roadmap for Uruguay



HyUruguay:

Development of a Green Hydrogen R&D Roadmap for Uruguay

Jochen Bard, Dayana Granford Ruiz (Fraunhofer IEE)

Jorge S. Gancheff, Carolina Pejo, Guillermo Valdomir (UdelaR)

Fraunhofer Institute for Energy Economics and Energy System Technology (Fraunhofer IEE)
Universidad de la República (UdelaR)

Date: 31/10/2025
Project partner: Universidad de la República. Montevideo, Uruguay.

Content

1 Introduction ... 5
2 Description of the methodology ... 6
3 Current hydrogen and PtX Market landscape in Uruguay ... 7

3.1 Current status in Uruguay ... 7
3.1.1 Energy situation ... 7
3.1.2 Renewable energy ... 9
3.1.3 Water resources ... 10
3.1.4 CO_2-resources ... 12
3.1.5 Infrastructure (ports, railways, pipelines) ... 13
3.1.6 Current relevant regulations (hydrogen, environmental and social) ... 17
3.1.7 Public and private Financing opportunities ... 19
3.1.8 International cooperations ... 21

3.2 Market analysis and country-specific benchmarking ... 22
3.2.1 Country analysis: Uruguay ... 22
3.2.2 Domestic and export markets for specific derivatives ... 22
3.2.3 Benchmarking resources and costs in Uruguay against other countries ... 26

3.3 Inventory 1: planned projects and actors in the country ... 27
3.3.1 Projects ... 27
3.3.2 Existing programs and initiatives ... 29
3.3.3 Actors and their roles (universities, companies, ministries, ANII) ... 30

3.4 Inventory 2: capacity building and research ... 31
3.4.1 Analysis of the current research and development situation ... 31
3.4.2 Analysis of the current capacity building ... 31

3.5 National strategy objectives and their priorities ... 33
3.5.1 Short-term, mid-term and long-term goals ... 33
3.5.2 Priorization of research focus areas ... 34

4 Analysis of current activities and relevant actors according to the methodology: SWOT Analysis ... 36

4.1 Introduction to the topic and objective of the analysis ... 36
4.2 Approach to conducting the SWOT analysis (including interviews) ... 37
4.3 Identification of internal strengths ... 37
4.4 Identification of internal weaknesses ... 39
4.5 Identification of external opportunities ... 40
4.6 Identification of threats ... 40
4.7 Mapping of Current Activities vs. Prioritization of Activities in the PtX Context ... 41
4.7.1 Results from the interviews ... 41
4.7.2 Prioritized activities based on the results ... 42

4.8 Relevance of Research and Development Topics ... 43
4.8.1 Research on CO_2 ... 43
4.8.2 Research on Synthesis ... 45

5 Development of the R&D roadmap ... 47

5.1 Objective and purpose of the roadmap ... 47

5.2 Implementation plan ... 47
5.2.1 Roadmap ... 47
5.2.2 Key stakeholders ... 48
5.3 Monitoring and evaluation ... 49
5.3.1 Continuous process of the roadmap ... 50
5.3.2 Strategies to ensure continuity ... 50
5.3.3 Institutionalization of the roadmap ... 51
5.4 Managing acceptance in research institutions ... 51
5.5 Stakeholder engagement and communication ... 52
5.6 Best practices and case studies ... 53
5.6.1 Successful examples from other countries or sectors ... 53
6 Conclusion and recommendations ... 56
6.1 Summary of key findings based on the analysis ... 56
6.2 Recommendations ... 57
7 Annex ... 60
7.1 Results from the interviews ... 60
8 Publication bibliography ... 62

1 Introduction

Uruguay has taken significant steps to establish itself within the global hydrogen and Power-to-X (PtX) landscape. Leveraging its strong renewable energy foundation, the country has launched pilot projects, initiated international cooperation agreements, and begun exploring potential export markets. A review of the current hydrogen and PtX market landscape reveals both opportunities and challenges: while Uruguay benefits from abundant renewable resources and a supportive policy environment, further investment in infrastructure, workforce development, and international partnerships will be crucial for scaling up.

To provide a structured overview, the roadmap includes an analysis of ongoing activities and relevant stakeholders, supplemented by a SWOT assessment and evaluations from stakeholder questionnaires. This analysis underscores Uruguay's key strengths—such as energy security, political stability, and international credibility—while also pinpointing gaps in research capacity, industrial readiness, and market development. The active participation of ministries, agencies, academia, and the private sector highlights the necessity for coordinated efforts among stakeholders.

Building on this foundation, the report introduces a dedicated R&D Roadmap that serves as a key element of Uruguay's national hydrogen strategy. The roadmap is structured into three distinct phases: foundation and early actions (2026–2028), scaling and demonstration (2029–2033), and integration and global competitiveness (2034–2040). Each phase specifies the activities to be undertaken, including research infrastructure development, workforce training, market establishment, and regulatory stability. This initiative is underpinned by a Monitoring & Evaluation Framework, which outlines the methods for tracking progress through annual reports, biannual stakeholder reviews, five-year independent evaluations, and a KPI dashboard aligned with international benchmarks.

The objective of this report and the accompanying roadmap is to provide a strategic framework that guides Uruguay in developing a sustainable and competitive green hydrogen and Power-to-X R&D landscape and further industry, facilitating informed decision-making and fostering collaboration among stakeholders to achieve national energy goals. By aligning strategic priorities with systematic monitoring, Uruguay is equipping itself with the tools necessary for evidence-based decision-making, policy adjustments, and an enhanced role in the global hydrogen economy. The involvement of international partners—such as the German Embassy and cooperation platforms with the EU—further ensures that Uruguay's R&D roadmap remains connected to global innovation and market trends.

2
Description of the methodology

This study utilizes a comprehensive methodology to examine the dynamics of the green hydrogen market in Uruguay. The process began with an extensive literature review, which involved collecting relevant information from academic articles, government reports, and industry publications. This review established a foundational understanding of the current landscape of green hydrogen technologies, policies, and market trends.

Subsequently, a mapping of key stakeholders in the green hydrogen market was conducted to identify essential players, including public entities, private companies, and research institutions. This mapping exercise provided valuable insights into the roles and contributions of various actors within the ecosystem, facilitating a clearer understanding of the collaborative dynamics at play.

To gather qualitative insights, questionnaires were developed and distributed, along with conducting interviews with stakeholders. The questionnaires were carefully designed to capture perspectives on existing challenges, opportunities, and the strategic direction of the green hydrogen sector. In-depth interviews with key figures, such as industry representatives and academic experts, were also carried out to collect firsthand accounts of their experiences and expectations regarding green hydrogen initiatives.

Finally, a SWOT analysis was performed to assess the strengths, weaknesses, opportunities, and threats associated with the green hydrogen market in Uruguay. This analysis synthesizes findings from the literature review, stakeholder interviews, and mapping exercise, offering a comprehensive overview of the current landscape. The results of this analysis will inform future strategic recommendations, guiding stakeholders in navigating the evolving green hydrogen ecosystem and optimizing their contributions to the sector's growth.

3
Current hydrogen and PtX Market landscape in Uruguay

3.1 Current status in Uruguay

3.1.1 Energy situation

This chapter provides an overview of the energy system infrastructure in Uruguay, highlighting the country's installed power capacity and the sources of electric power generation. Uruguay's energy supply is primarily derived from four hydroelectric plants situated along the Río Uruguay and Río Negro, complemented by thermal power plants using steam turbines, gas turbines fueled by fossil fuels and biomass, and an increasing contribution from wind and solar generation farms. This diverse energy mix not only ensures a reliable electricity supply but also aligns with Uruguay's goals for sustainable energy transition and reduced carbon emissions.

Transmission lines infrastructure: With a network of 83,277 km, electrification reaches 99.8% of the country's homes. The national electrical system consists of two large high-voltage transmission networks mainly at 150 kV (Table 1) (Enel foundation 2019). Uruguay is also electrically connected to Argentina with a capacity of 2,000 MW and to Brazil with a capacity of 570 MW. The geographical distribution of electricity generators in Uruguay is indicated in Figure 1. The electrical generators are composed of 42 wind power plants, 4 hydroelectric power plants, 17 solar photovoltaic generators, 12 thermal power plants (biomass) and 4 thermal power plants (fossil fuels) (Balance Energético Nacional Uruguay 2024).

Table 1. Voltage levels in kV and extensions of transmissions lines in Uruguay (Enel foundation 2019).

Voltage level (kV)	Total length (km)
150	3,923
230	11
500	1,078

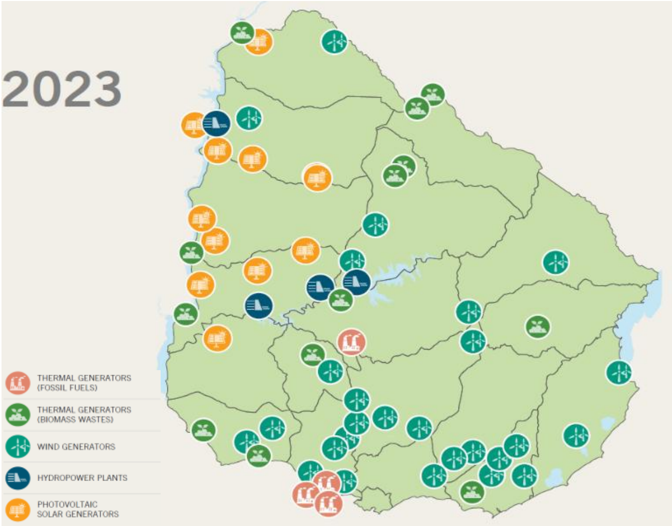


Figure 1. Geographical distribution of electricity generators in Uruguay) (Balance Energético Nacional Uruguay 2024).

Installed power capacity: Uruguay's installed power capacity consists of both renewable and non-renewable resources. As of 2023, the total installed capacity was 5,263 MW, with 78% coming from renewable sources such as hydro, biomass, wind, and solar energy, and 22% from non-renewable sources like diesel, fuel oil, and natural gas. The total installed capacity increased by 7% in 2023, primarily due to a 75% rise in biomass capacity and a 7% increase in solar photovoltaic installations. Although the hydropower generation capacity has not changed, its share of the total installed capacity has decreased from 60% in 1967 to 29% in 2023, mainly because of the growth of other renewable sources, particularly wind energy. In terms of thermal power, the "Punta del Tigre" plant is essential for meeting domestic electricity demand and plays a role in exporting energy to neighboring countries as well. This plant is expected to serve as thermal backup for the next 30 years) (Balance Energético Nacional Uruguay 2024).

Electric power generation: In 2023, total electricity production reached 12,877 GWh, with renewable energy sources accounting for 92% of this output, while the remaining 8% was derived from fossil fuels. Public service power plants contributed approximately 10,817 GWh, representing 84% of the total generation, whereas self-generation facilities produced around 2,060 GWh, or 16%. Domestic electricity demand was met 89% by national production, with significant supplemental imports of approximately 1,396 GWh from neighboring countries. Additionally, the country exported 244 GWh of electricity, with over 50% originating from hydroelectric power and 2% from fossil fuels. Of the exported electricity, 94% was directed to Argentina and 6% to Brazil (Balance Energético Nacional Uruguay 2024).

Primary energy supply: Figure 2 illustrates Uruguay's primary energy matrix for 2023, which comprises: 32,622 GWh from biomass, 27,482 GWh from oil and oil derivatives, 4,768 GWh from wind energy, 3,512 GWh from hydroelectricity, 768 GWh from natural gas, and 582 GWh from solar energy (both photovoltaic and thermal). Additionally, electricity imports totaled 1,396 GWh, resulting in a total energy supply of 71,245 GWh (6,126 ktoe) for this year. In 2023, Uruguay's energy matrix consisted of 58% renewable sources, 40% non-renewable sources, and 2% imported electricity) (Balance Energético Nacional Uruguay 2024).

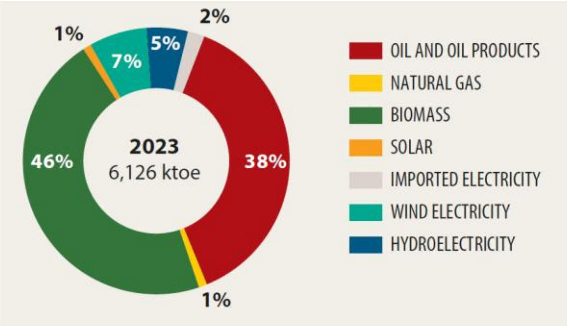


Figure 2. Primary energy matrix in Uruguay) (Balance Energético Nacional Uruguay 2024)

Oil products supply: The refinery (ANCAP) commenced its planned maintenance shutdown in September 2023. Production of oil derivatives fell by 31% compared to the previous year, while imports surged by 140%. Production of petroleum derivatives amounted to 17,084 GWh/a in this year. The primary product was diesel oil (8,106 GWh/a), followed by automotive gasoline (5,106 GWh/a) and fuel oil (1,361 GWh/a). As "own consumption" in the refineries, 488 GWh/a of fuel oil and 233 GWh/a of petroleum coke were produced) (Balance Energético Nacional Uruguay 2024).

Energy demand: In 2023, Uruguay's total energy consumption reached a record 62,069 GWh. The industrial sector remained the largest consumer, representing 48% of total energy use, a consistent trend since 2008. This was followed by the transportation sector at 26%, residential use at 16%, commercial/services/public sectors at 6%, primary activities at 3%, and unidentified consumption at 1%. According to (Balance Energético Nacional Uruguay 2024), the growth in final energy consumption recorded in 2023 was mainly due to the increase in the industrial sector (manufacturing and construction), since the residential, commercial/services/public sector and transportation sectors recorded decreases.

3.1.2 Renewable energy In terms of renewable energy, Uruguay currently has capacities in hydro, wind, and solar energy. In 2023, the country achieved high percentages of variable renewable energy generation with a maximum daily share from renewable energies of 90% (REN21 2024) and ranks among the top countries with the highest share of renewable electricity generation. In the medium- to long-term, Uruguay has the potential to install new renewable energy generation sources.

Uruguay's electricity generation matrix is composed of 92% renewable sources. As shown in Figure 3 wind generation leads with a 37% share, followed by hydroelectric power at 27%, biomass at 24%, and solar at 4%. In contrast, fossil fuel-based electricity accounts for 8% of the total (Balance Energético Nacional Uruguay 2024). Key observations for 2023 include a decreased contribution from hydroelectric power due to drought conditions, a significant amount of unused energy from hydro, wind, and solar sources due to low electricity demand, and an increase in thermal generation from biomass following the launch of the third pulp mill.

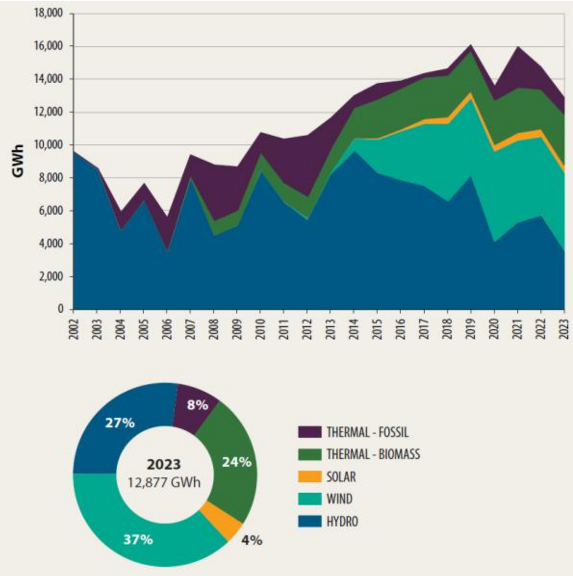


Figure 3. Electrical generation in 2023 by source (Balance Energético Nacional Uruguay 2024)

3.1.3 Water resources

In terms of water resources, Uruguay has six major river basins: the Río Uruguay (113,608 km^2), the Río de la Plata (34,016 km^2), Laguna Merín (28,777 km^2), the Río Negro (68,216 km^2), the Río Santa Lucía (13,487 km^2), the Atlantic Ocean (Ministerio de Ambiente 2025). Surface water constitutes the main source of water supply, with 87% used for irrigation, 11% for domestic purposes, and 2% for industrial activities. Irrigation is the predominant use in most basins; however, in the Río Santa Lucía basin, domestic use is more common, while industrial use is predominant in the Río de la Plata (Mapeko 2022).

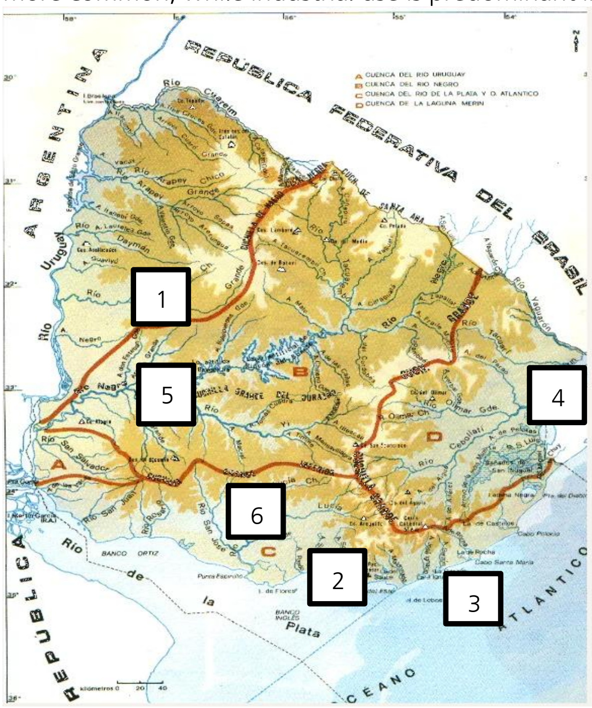


Figure 4. Map of main basins in Uruguay. 1) Río Uruguay, 2) Río de la Plata, 3) Atlantic Ocean, 4) Laguna Merín, 5) Río Negro, 6) Río Santa Lucía (Ministerio de Ambiente 2021) (Mapeko 2022).

The Río Uruguay and Río Negro have the highest concentration of large dams in the country, primarily for hydroelectric power generation, with a total storage capacity of 17.3 km^3 (Mapeko 2022). Among the major dams are:

- Salto Grande dam, which is located on the Río Uruguay and has an electricity generation capacity of 1,890 MW with a storage capacity of 5 km^3
- Rincón del Bonete dam, situated on the Río Negro with a generation capacity of 160 MW and a storage capacity of 8.8 km^3
- Baygorria dam, which is located on the Río Negro with an electricity generation capacity of 108 MW and a storage capacity of 0.6 km^3
- Palmar dam, located on the Río Negro. This dam has an electricity generation capacity of 333 MW and a storage capacity of 2.85 km^3.

There are also other dams for industrial and irrigation purposes on the Río Santa Lucía and small private ponds, primarily for irrigation, with an estimated total capacity of 1.4 km^3 (Mapeko 2022). Regarding aquifers, the Acuífero Guaraní represents one of the most important groundwater reserves of fresh water and has a water potential of 40,000 km^3. As indicated in Figure 5, this aquifer is shared between the territories of Argentina, Brazil and Uruguay. In Uruguay, this aquifer occupies an area of 43,000 km^2 (Portal Educativo).

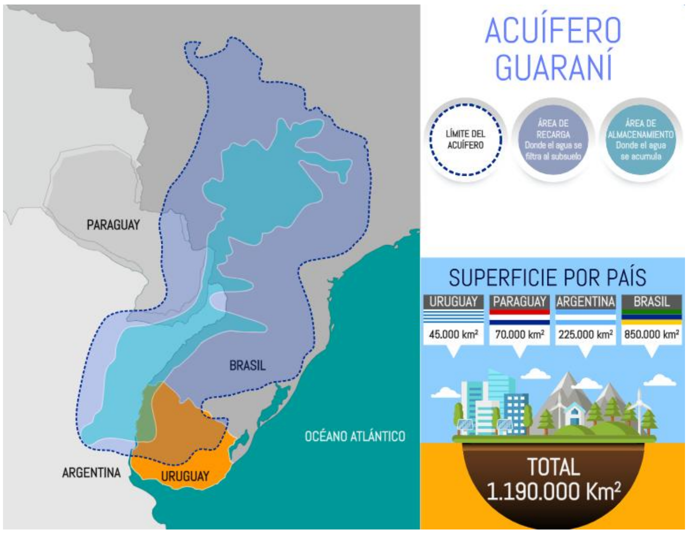


Figure 5. characteristics of the Acuífero Guaraní (Portal Educativo)

In total, Uruguay currently has approximately 92,000 million m^3/a of water available (Brener 2024; Universidad Católica del Uruguay 2024). The current uses authorized by DINAGUA for all nationwide activities amounted to 4,400 million m^3 in 2022, which consumption represents about less of the 5%. According to (Ministerio de Industria, Energía y Minería 2023a) the additional water requirements to supply the production of green hydrogen and derivatives in Uruguay were estimated to represent an additional water demand of less than 1%. Figure 6 indicates the potential water consumption identified for the National Roadmap for green hydrogen and its derivatives in 2040.

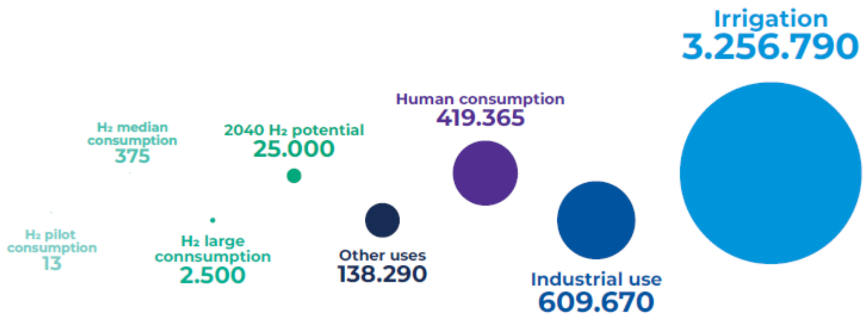


Figure 6. Water consumption authorized by DINAGUA - comparison with H2 projects and roadmap potential (thousands of m³/a) (Ministerio de Industria, Energía y Minería 2023a)

3.1.4 CO_2-resources

In 2024, over 11.36 Mt/a of CO_2 emissions were unavoidable, linked to industrial activities in the country. As shown in Figure 7, the primary source of CO_2 emissions is biogenic, originating from cellulose plants, which account for more than 9.3 Mt/a of emissions, representing 82% of the total CO_2 output. These biogenic sources are mainly situated in the southwest region of Uruguay (Ministry of Economic Affairs and Climate Policy of the Netherlands 2024), (Vukasovic and Messina 2024a). Furthermore, most of the rest of the emissions are distributed to some industrial conglomerates, especially in the following areas (Vukasovic and Messina 2024a):

- Northern Conglomerate (Tacuarembó and Rivera) with 0.6 Mt/a, representing 5% of the total CO_2 emissions. The sectors within this conglomerate are sawmills, electricity generation based on biomass residues and refrigeration plants
- Northern Litoral Conglomerate (Paysandú and Artigas): 0.4 Mt/a (4% of total); Sectors: biofuels and cement
- Eastern Conglomerate (Lavalleja and Treinta y Tres): 0.4 Mt/a (4% of the total); Sectors: cement, lime and beer production
- Rest: 0.6 Mt/a (5% of the total); Sectors: mills, meat packing plants and sawmills.

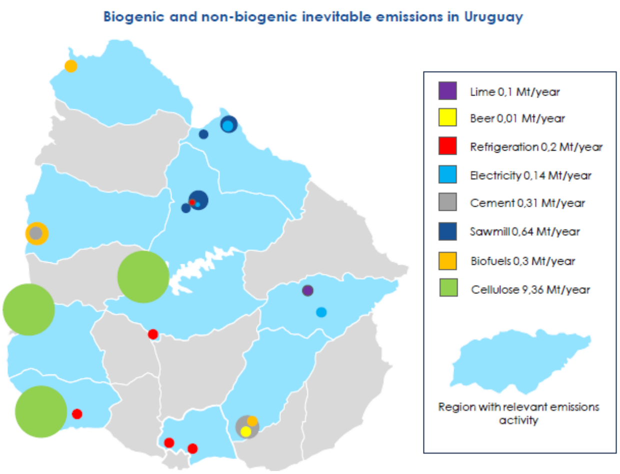


Figure 7. CO_2 Sources in Uruguay (Ministry of Economic Affairs and Climate Policy of the Netherlands 2024)

3.1.5 Infrastructure (ports, railways, pipelines)

Port Infrastructure: Uruguay's maritime infrastructure features a blend of deep-water hubs and a network of regional and private terminals, creating a strong foundation for future logistics related to green hydrogen. In 2022, the Uruguayan port system achieved a total cargo volume of approximately 20 million tons, distributed among the country's seven ports (INEFOP), (Ámbito 2023) .

- Port of Montevideo: This port led operations with a total of 17.4 million tons handled, including both bulk cargo and containers. Additionally, it reached a historic milestone by handling over 1 million TEUs (Twenty-foot Equivalent Units), solidifying its position as one of the major ports in Latin America and the Caribbean in terms of container activity.
- Port of Nueva Palmira: This port managed 2.1 million tons, distributed among exports (40%), imports (23%), and transshipments (37%), primarily sourced from the Paraguay-Paraná waterway.
- Other Ports: The ports of Paysandú, Juan Lacaze, Colonia, Fray Bentos, and La Paloma collectively handled a total of 1.5 million tons, distributed across exports, imports, and transit.

The Port of Montevideo, the main deep-water entry point, is currently undergoing extensive modernization, supported by an investment of around USD 460 million (Katoen Natie 2021). This upgrade includes the installation of new STS cranes, the introduction of shore power ("cold-ironing") facilities, and the expansion of a 14-meter dredged access channel, (Global Construction Review 2021). These improvements will enable the port to accommodate ships with a capacity of up to 578,000 m³ (approximately 15,000 TEU) (Freight Amigo) and position it, under the management of logistics company Katoen Natie, as a strategic launch pad for ammonia and e-fuel exports. Additionally, the port of Nueva Palmira, situated along the Paraguay-Paraná waterway, functions as a free-trade bulk hub, effectively linking the hinterland to the Río de la Plata. This port is increasingly handling transshipments of grain and mineral ores, enhancing its role in regional logistics (Administración Nacional de Puertos 2024b), (Instituto Nacional de Logística 2016).

In addition to these major ports, the Administración Nacional de Puertos (ANP) oversees a network of river and coastal ports that further expands Uruguay's export capacity (Administración Nacional de Puertos 2024a). Key ports in this network include Colonia del Sacramento, which services ferries and short-sea cargo; Fray Bentos and Paysandú, which handle bulk and barges; Salto, catering to passenger and light freight (Administración Nacional de Puertos 2025) and Juan Lacaze and Carmelo, which focus on cabotage and tourism. Private free trade zones, such as the Navíos and ONTUR terminals in Nueva Palmira (specializing in grains and iron ore), Montes del Plata, and UPM’s facilities for pulp and biomass, as well as ANCAP’s single point mooring at José Ignacio for crude imports, further enhance capacity. Several smaller industrial piers also manage the handling of cement, fertilizers, and fuels (INEFOP), (INALOG and Uruguay XXI 2016).

Uruguay is also exploring the development of inland ports in the Laguna Merín basin, a historically underutilized region in the northeast bordering Brazil. A feasibility study conducted by CERES suggests that establishing an inland waterway could significantly boost agricultural exports (including rice, corn, and limestone), improve regional connectivity with southern Brazil, and stimulate socioeconomic development in one of the country's most vulnerable areas. Although still in the preliminary stages, this initiative reflects Uruguay's commitment to diversifying its logistics infrastructure and utilizing river corridors to support long-term hydrogen trade (CERES 2021).

This distributed network provides Uruguay with multiple potential sites for hydrogen bunkering, ammonia storage, and component assembly yards, thereby reducing reliance on Montevideo alone and enhancing resilience along the Río de la Plata, Río Uruguay, and potentially the Laguna Merín corridors.

Other port developments are attributed to the investment of a Uruguayan Argentine consortium for the creation of a multipurpose port in La Paloma, Rocha, referred to as the "La Paloma Hub". This project aims to transform the La Paloma area into an international logistics center, with a central focus on green hydrogen logistics and synthetic fuels. The project is currently under evaluation by Uruguayan authorities and involves an investment of 1.6 billion dollars (Parks 2023), (InfoNegocios 2023), (CLM 2023).

Figure 8 and Figure 9 present a map of the country's ports, as well as a detailed map of the Port of Montevideo

Figure 8. Map of ports in Uruguay (Own illustration)

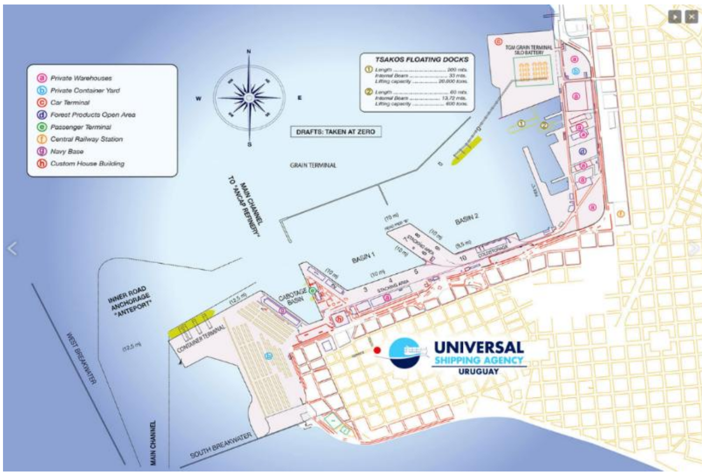


Figure 9. Port of Montevideo. TGM: Terminal Granelera Montevideo; TCP: Terminal Cuenca del Plata; ANP: Administración Nacional de Puertos (Universal Shipping Agency - Uruguay, 2025)

Railway Infrastructure: Uruguay's railway network covers about 2,957 kilometers (Ministerio de Transporte y Obras Públicas 2024), categorized into:

Table 2. Length of railway infrastructure in Uruguay (Ministerio de Transporte y Obras Públicas 2024)

Category	Length (km)
Central Railway	271
General Active Network	1,121
Inactive Network	1,465

The sector is evolving in response to national policies and industry needs, particularly in renewable energy, forestry, and agro-export (Ministerio de Transporte y Obras Públicas 2024). A significant initiative is the Central Railway, a USD 1.2 billion public-private partnership that upgraded the route from Paso de los Toros to Montevideo’s port. Since becoming operational in 2024, it has the capacity to transport 4 Mt of cargo each year (BID Invest 2022), (Ministerio de Transporte y Obras Públicas 2020). Other routes include:

- The Rivera Line (Paso de los Toros to Rivera) supports cargo trains at 40 km/h with 18 tonnes per axle (Ministerio de Transporte y Obras Públicas (MTOP) & Administración de Ferrocarriles del Estado)
- The Minas Line (Montevideo to Lavalleja) and Río Branco Line (Toledo to Treinta y Tres) are also operational, albeit at lower capacities and with ongoing infrastructure constraints (Ministerio de Transporte y Obras Públicas (MTOP) & Administración de Ferrocarriles del Estado)
- A segment of the Litoral Line, from Chamberlain to Queguay, remains in use, but the rest is under re-evaluation for rehabilitation (Ministerio de Transporte y Obras Públicas (MTOP) & Administración de Ferrocarriles del Estado).

The railway modernization supports Uruguay's port upgrades and aims to enhance sectors like green hydrogen by facilitating the transport of heavy and sensitive components (e.g., electrolysers, cryogenic tanks) from inland production sites to maritime terminals. By reactivating several railway lines by 2030, including the rehabilitation of the Río Branco Line and the completion of the Coastal Line (Chamberlain-Salto), Uruguay can effectively position itself in the green hydrogen and PtX market. Ongoing modernization and rehabilitation efforts include enhancing the railway connection between La Teja and the ANCAP plant (Railway Gazette International 2025), (Ministerio de Transporte y Obras Públicas 2024). These projects could significantly enhance the coverage and flexibility of the railway network.

Figure 10. Railway infrastructure in Uruguay (Desarrollo & Inversión, 2025; Instituto Nacional de Logística, 2025)

Although Uruguay has actual international rail links (e.g., Salto–Concordia and Rivera–Livramento), the railways are currently limited in their regular international use, and active operating agreements are minimal or nonexistent. Their rehabilitation and commissioning are being evaluated within the framework of Uruguay's strategy to integrate into regional logistics and energy corridors (World Bank), (Ministerio de Industria, Energía y Minería 2023a), (Administración de Ferrocarriles de Estado).

Gas Pipelines Infrastructure: Uruguay's existing natural gas infrastructure, primarily designed for fossil gas, holds significant potential for adaptation to green hydrogen. The country imports all its natural gas through pipelines from Argentina. The main pipeline, the Cruz del Sur pipeline (Figure 11), built in 2002, spans 215 km and connects Buenos Aires to Montevideo (via Colonia), with a capacity of about 1.8 billion m3/a. This pipeline, partially managed by ANCAP (Uruguay's state-owned energy company), supplies gas for electricity generation and industrial use (Global Energy Monitor Wiki 2025a), (OECD/IEA 2003).

Additionally, a secondary pipeline called Gasoducto del Litoral runs along the western border, serving industrial areas near Colón and Paysandú. Although Uruguay does not produce natural gas domestically, there were plans in 2013 for an LNG regasification terminal (GNL del Plata) in Punta de Sayago, linked to the Cruz del Sur pipeline (Global Energy Monitor Wiki 2025b), (bnamericas 2016), (Offshore Energy 2013). This project is currently cancelled (Global Energy Monitor Wiki 2025b) .

Figure 11. Gasoducto Cruz del Sur S.A. (GCDS) runs from Punta Lara in Argentina to Montevideo and its surrounding areas in Uruguay, traversing the departments of Colonia, San José, Canelones, and Montevideo (Gasoducto Cruz Del Sur, 2025)

3.1.6 Current relevant regulations (hydrogen, environmental and social)

Institutional and Legal Foundations: Uruguay has established a coordinated approach to develop hydrogen through the H2U inter-institutional program. A 2022 presidential resolution created H2U, convening all relevant public agencies (e.g., energy, environment, transport and finance) to jointly implement green hydrogen initiatives (Ministerio de Industria, Energía y Minería 2024b). This ensures that ministries, regulators, and state companies work together on hydrogen policy and regulations. Recent legislation has also assigned clear institutional roles. For example, the 2021 national budget law expanded the mandate of the Energy and Water Services Regulator (URSEA) to include oversight of hydrogen activities (Ministerio de Industria, Energía y Minería 2024b). Likewise, the 2022 budget law authorized the state energy company ANCAP to "produce, distribute, commercialize, import and export green hydrogen and its derivatives" in open competition (Ministerio de Industria, Energía y Minería 2024b). These legal changes signal strong government support by empowering key institutions to engage in the hydrogen sector.

Regulations for Hydrogen Production, Use, and Export

Hydrogen Production: Uruguay currently lacks specific regulations for hydrogen production. Historically, hydrogen was produced at ANCAP's La Teja refinery for internal use through natural gas reforming, following ANCAP's safety protocols based on ASME standards. For new green hydrogen projects, such as those using electrolysis, there is no dedicated permitting framework beyond general industrial and energy regulations. Developers must adhere to standard industrial safety codes and electricity sector regulations. For example, large electrolysis plants that connect to the grid require a generation permit and grid interconnection approval. Currently, there is no guarantee-of-origin certification for green hydrogen, but Uruguay's renewable electricity certificate system (SCER) may potentially be adapted to certify renewable hydrogen in the future (Vukasovic and Messina 2024b).

Hydrogen Use (Domestic): Hydrogen is currently regulated via analogies to other gases, with no explicit codes for its use as a fuel in transportation. While there are regulations for compressed natural gas (CNG) vehicles, these have never been implemented in Uruguay. Additionally, standards for hydrogen fuel quality and permissible blending with natural gas are undefined. A planned pilot project that injects hydrogen into the gas grid e.g., in Paysandú, will necessitate the development of new regulations (Vukasovic and Messina 2024a). For industrial applications, such as using hydrogen as feedstock or in power generation, general hazardous substances controls apply. Existing gas installation codes (URSEA's 2014 regulation for fixed gas installations) allow the use of international standards (ASME, NFPA, ISO) for gases not covered by current regulations, serving as a temporary measure that permits hydrogen facilities to follow best practices with regulatory approval. In summary, while there are no specific technical standards for hydrogen, global standards are applied on a case-by-case basis (Vukasovic and Messina 2024b).

Hydrogen Transportation and Export: Uruguay currently lacks specific regulations for hydrogen transport infrastructure, including pipelines and export terminals. To support future hydrogen pipelines, Article 237 of Law 20,075/2022 establishes a legal framework for easements, allowing rights-of-way for pipelines and related facilities. However, detailed regulations covering materials, pressure, and safety remain to be developed (Ministerio de Industria, Energía y Minería 2024b).

In the meantime, road transport of hydrogen is governed by existing dangerous goods transport regulations. Compressed or liquefied hydrogen in cylinders or tankers must comply with the national hazardous materials transport code (Decree 560/003), which aligns with MERCOSUR standards, and requires permits from transport authorities and fire departments, similar to LPG and industrial gases (Vukasovic and Messina 2024b). For maritime export, Uruguay will follow international shipping regulations (e.g., IMO codes). The National Ports Administration is part of the H2U group and is assessing port readiness, but specific domestic regulations for handling ammonia, methanol, or liquid hydrogen exports are still under development.

Environmental and Social Regulatory considerations

Uruguay's environmental laws and permitting processes will play a pivotal role in hydrogen project development. The following regulatory aspects concerning environmental and social criteria are considered in the country:

- Environmental Impact Assessment (EIA): Since 1994, significant new projects, including large green hydrogen plants, must undergo an EIA and obtain Prior Environmental Authorization (Decree 349/005) (IMPO 2005). Projects like electrolyser facilities exceeding certain capacities or requiring major transmission lines will trigger an EIA.
- Water Usage Regulations: Hydrogen projects utilizing water for electrolysis or cooling must secure water use rights from the National Water Directorate (DINAGUA). Any extraction over 500 liters/second or the creation of large reservoirs necessitates a full environmental assessment and permit, ensuring responsible management of water resources in line with Article 47 of the Constitution (Ministerio de Industria, Energía y Minería 2023a), (IMPO 2009), (IMPO 1978).
- Land Use and Social Safeguards: Under the Land Use and Sustainable Development Law 18,308 (2008), projects must comply with local zoning plans. Municipalities manage land categorization, and hydrogen plants may require re-zoning if located on rural land not designated for industrial use. Public participation is encouraged through EIA hearings and land-use plan updates, allowing communities to express concerns (IMPO 2008).
- Environmental Standards: Uruguay's Environmental Protection Law (Law 17,283/2000) sets standards for effluents, waste, and air emissions relevant to hydrogen production facilities (IMPO 2000).
- Ministry of Environment: Established in 2020, this ministry emphasizes rigorous environmental oversight (IMPO 2022), (IMPO 2020).
- Stakeholder Engagement: While there is no specific "social license" legislation for hydrogen, Uruguay's strong rule-of-law tradition provides clear guidelines for investor engagement and mitigation of environmental or social impacts (IMPO 2005), (IMPO 2000).

3.1.7 Public and private Financing opportunities

Uruguay is establishing a combination of public funding programs and private investment incentives to stimulate its green hydrogen sector. Although specific financing tools for hydrogen are still developing, the country is utilizing broader renewable energy funds and robust public-private partnerships to support hydrogen initiatives. The following provides an overview of existing financing instruments, key programs, involved stakeholders, and emerging tools under consideration.

Public Funding and Incentive Programs

Uruguayan authorities have launched several initiatives to directly fund green hydrogen development and create a favorable investment climate:

- Green Hydrogen Sector Fund (Fondo Sectorial de Hidrógeno Verde) (Ministerio de Industria, Energía y Minería 2024a): In 2022, the Ministry of Industry, Energy and Mining (MIEM), the National Research and Innovation Agency (ANII), and the technology laboratory LATU established a dedicated fund to finance research, innovation, and training in green hydrogen and its derivatives. Through this fund, the government held a competitive call for Uruguay's first green hydrogen pilot project, offering up to USD 10 million in non-reimbursable grants to the winning proposal. The selected consortium (project "H24U") is required to design, finance, build, and operate a pilot-scale hydrogen production and use project, with the grant disbursed over up to 10 years of operation. This public subsidy helped catalyze the country's inaugural green hydrogen plant, which will supply fuel for heavy transport.
- Research & Innovation Support (Ministerio de Industria, Energía y Minería 2023b): Uruguay continues to support hydrogen R&D through existing energy innovation funds. For example, the Energy Sector Fund (Fondo Sectorial de Energía) administered by ANII has been used to finance hydrogen-related research projects and researcher training, bolstering domestic know-how. These programs aim to build local scientific and technical capacities in hydrogen technologies, in coordination with the National Innovation, Science and Technology Council (CONICYT).
- Tax Incentives under Investment Promotion Laws: Uruguay offers generous tax benefits to renewable energy and clean fuel investments. Under the Investment Promotion Regime (Law No. 16,906), projects in priority sectors can receive corporate income tax exemptions and other fiscal benefits. In practice, producers of biofuels and e-fuels enjoy 100% income tax exemption for 10 years, as well as exemptions on wealth and import taxes for relevant assets (Uruguay XXI 2025). Green hydrogen and its derivative fuels are expected to qualify under these incentive frameworks as part of the country's push for value-added green exports (Ministerio de Industria, Energía y Minería 2023b). The government has committed to put in place "a set of attractive incentives" and streamlined permits to encourage hydrogen investments.
- State-Owned Enterprises and Public Investment: Uruguay's public energy companies are playing a facilitating role. The state electricity utility UTE and the national oil company ANCAP are empowered to participate in hydrogen projects, for instance, ANCAP has been authorized by MIEM to pursue offshore wind opportunities for hydrogen production (IMPO 2024). These companies can form joint ventures, provide land or infrastructure, and help de-risk projects (IMPO 2011). UTE has also received technical assistance (e.g. a USD 100,000 grant from

CAF[1] development bank) to study green hydrogen production and commercialization models, illustrating how public funds are used to prepare the groundwork for future projects (CAF 2023a).

- International Grants and Cooperation: Uruguay is leveraging international climate finance to support its hydrogen roadmap. The European Union (through its EUROCLIMA+ program) committed 2 million euros in grant funding to Uruguay in 2024 to strengthen green hydrogen development (GH2). This non-reimbursable contribution supports capacity building, regulatory framework upgrades, and public awareness for hydrogen. Likewise, technical cooperation with Germany (via the BMFTR and BMWE) and multilateral agencies (IDB, UNDP/UNIDO through the Joint SDG Fund) is bringing in expertise and seed funding for studies, policy design and pilot initiatives. These collaborations do not finance large projects directly but help Uruguay create an enabling environment and project pipeline for green hydrogen (Federal Ministry for Economic Affairs and Energy 2023), (UNIDO 2021; International Development Bank 2023), (Inter-American Development Bank 2019).

Private Investment and Public-Private Partnerships

Given Uruguay's strategy relies on attracting private capital, several financing opportunities and partnerships are emerging on the private side, often backed by blended finance:

- Pilot Project Finance – "Kahiros" and H24U: The country's green hydrogen pilot plants showcases blended financing: in addition to the USD 10 million government grant for the H24U project (Estratégica 2023), the Kahiros consortium secured a USD 39 million loan from commercial lenders to cover project costs. The pilot's successful funding underscores that domestic banks and investors are willing to back hydrogen projects when incentivized by public support and off-take agreements (Isabella Ankerson 2024).

- Domestic Banks and Blended Finance Vehicles: Uruguay's banking sector is actively being engaged to finance the clean energy transition. A flagship mechanism is the Renewable Energy Innovation Fund (REIF) – a trust fund supported by the UN Joint SDG Fund and Uruguayan government that blends public and private capital. REIF provides loans on flexible terms to renewable energy and clean tech projects, including "Power-to-X" initiatives for green hydrogen production (Joint SDG Fund 2023). With an initial public capitalization of USD 7 million, REIF has leveraged around USD 68 million from local banks (such as BROU, Santander, Itaú, and HSBC) to co-finance projects via dedicated credit lines. This innovative financing window targets small- and medium-businesses and pilots (loans typically USD 30k– USD100k) to spur early-stage hydrogen use cases alongside electric mobility and storage solutions (Joint SDG Fund 2023). Commercial banks in Uruguay are thus gaining experience in green hydrogen financing through risk-sharing arrangements, which will be crucial as the industry scales.

- Foreign Direct Investment and Joint Ventures: Uruguay's reputation as a stable, renewable-rich country is attracting international investors for large-scale hydrogen and e-fuels projects. For instance, ANCAP has partnered with HIF Global (backed by Porsche) to assess a USD 4 billion green hydrogen and e-fuels plant

[1] Corporación Andina de Fomento - Banco de Desarrollo de América Latina y el Caribe

in Paysandú. While these ventures will be privately financed, with companies like HIF providing equity and raising project finance debt, the government supports them through competitive tendering, land access, and policy initiatives (Lucinda Elliott 2023). Additionally, Uruguay has signed cooperation agreements with ports (such as Rotterdam) and foreign governments to promote investment in export-oriented hydrogen supply chains (Djunisic 2023). These early commitments from international firms indicate that substantial private capital is ready to flow into Uruguay's hydrogen sector as successful pilot projects are scaled up (Lucinda Elliott 2023).

- Multilateral Development Bank Support: While most hydrogen investment will primarily come from the private sector, development banks are anticipated to play a crucial role in mitigating risks associated with large projects. The Inter-American Development Bank (IDB) and CAF are already providing advisory financing and may offer concessional loans or guarantees for hydrogen infrastructure in the future, like their previous support for Uruguay's renewable energy expansion (Ros 2024). Uruguay's participation in green finance initiatives, such as issuing a climate-linked sovereign bond and developing a green taxonomy, could also facilitate access to lower-cost capital for hydrogen projects through green bonds or climate funds (Montevideo Portal 2025). Although there is currently no hydrogen-specific loan program, Uruguay's solid credit and sustainability record enables project developers to access international climate finance and export credit agencies when constructing large electrolyser facilities or export terminals.

3.1.8 International cooperations

Building on its long-standing tradition of collaborative diplomacy, Uruguay has consistently demonstrated its commitment to international cooperation, actively seeking and strengthening global partnerships to advance its promising green hydrogen sector, and renewable energies. In November 2022, MIEM signed an MoU with Germany's BMFTR to enhance collaboration in energy research and innovation. Additionally, in March 2023, Uruguay established an Energy Partnership with Germany's BMWE, focusing on green hydrogen, energy efficiency, and battery storage (GIZ 2024). The Netherlands has also engaged in collaboration, with both countries issuing a joint statement in 2021 to develop green hydrogen export-import corridors (Government of the Netherlands 2025).

In July 2023, Uruguay signed an MoU with the European Union to promote cooperation in renewable energies, including green hydrogen, policy exchanges, and industrial investments (EEAS 2025). Development banks are also supporting this transition, with the Development Bank of Latin America and the Caribbean (CAF) providing USD100,000 in technical assistance to UTE for a pilot project on hydrogen production and commercialization (CAF 2023b).

Uruguay has been active in global forums, including the 2024 World Hydrogen Summit in the Netherlands, where it showcased investment opportunities and ongoing projects. These efforts position Uruguay as a future producer of green hydrogen, leveraging international alliances to drive its energy transition (Uruguay XXI 2024).

3.2 Market analysis and country-specific benchmarking

3.2.1 Country analysis: Uruguay

Uruguay has good solar and wind resources, allowing for high-capacity factors in the electrolyser and low hydrogen production costs. The western regions exhibit the best characteristics for generating solar energy, while the areas with the best wind characteristics are located at the border between the departments of Rivera, Tacuarembó, and Salto, and between Lavalleja, Florida, and Treinta y Tres. Figure 12 displays the wind and solar map of Uruguay created by (Universidad Católica del Uruguay 2024).

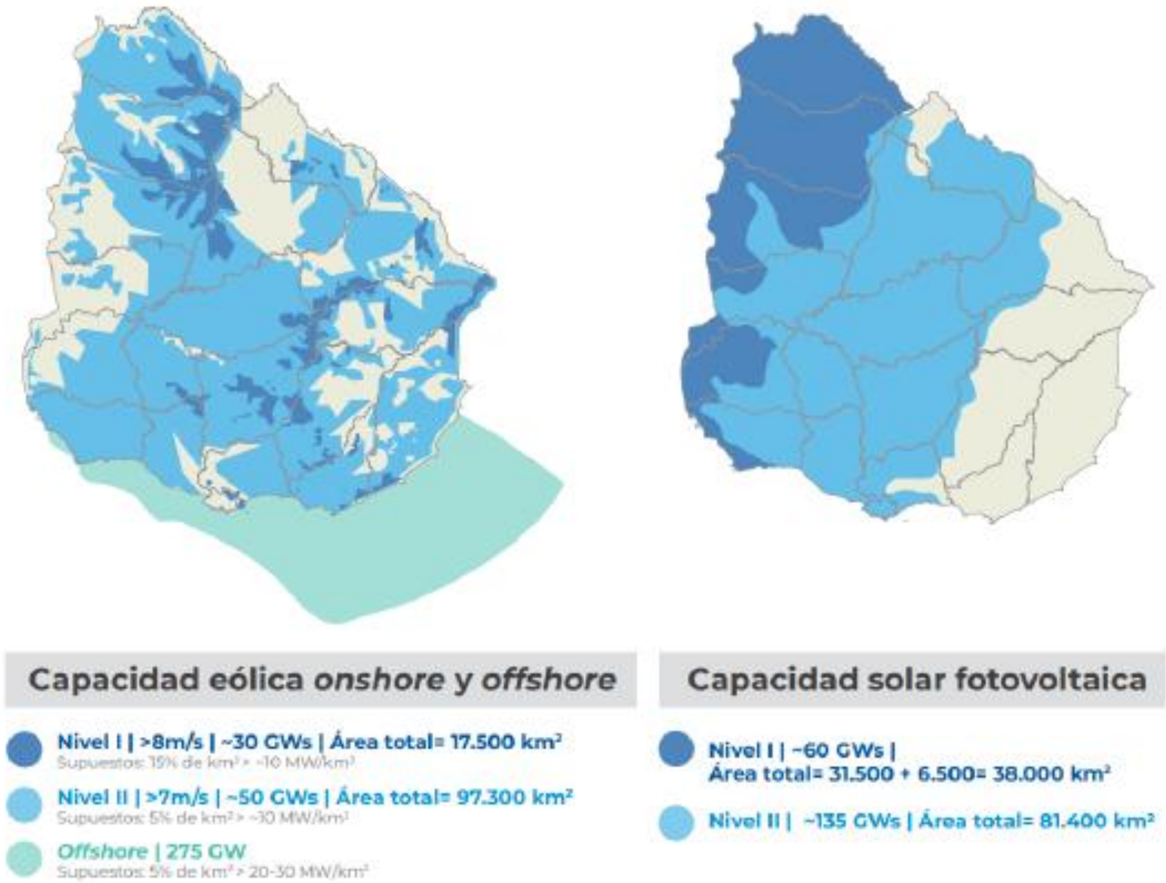


Figure 12. Solar and Wind capacities for Uruguay (Universidad Católica del Uruguay 2024)

Onshore wind capacity in Uruguay is classified into two capacity levels, whose value changes based on factors such as wind speed (m/s) and the percentage of the permitted area for hydrogen project development (%/km²). According to this map, the total onshore wind capacity in Uruguay is estimated at 30 GW for level 1 and 50 GW for level 2. Additionally, the chart shows that offshore wind capacity is 275 GW. Solar capacity in the country is similarly divided into two levels. The first level, situated in the northwest, represents a solar capacity of 60 GW, while the second level, which covers the area from the west to the center of the country, indicates a total capacity of 135 GW (Universidad Católica del Uruguay 2024), (Ministerio de Industria, Energía y Minería 2023a).

3.2.2 Domestic and export markets for specific derivatives

The domestic hydrogen market in Uruguay is still in its early stages, with ANCAP being the primary consumer of hydrogen through its oil refining processes (Ministerio de Industria, Energía y Minería 2021)

Ammonia and Fertilizers:

The ammonia market in Uruguay is characterized by a significant reliance on imports. In 2023, Uruguay imported approximately 7 GWh/a of anhydrous ammonia, with its main suppliers being Brazil (85.9%) and Argentina (14.1%) (Veritrade 2025). On the other hand, urea is the most widely used fertilizer in Uruguay. In 2021, Uruguay imported approximately 838 GWh/a of urea, valued at USD 152 million (average cost of USD 458/ton) (El Pais 2023).

Methanol:

In Uruguay, there is no industrial plant dedicated to the conventional production of methanol. National production is restricted to small quantities used in laboratories, research, and certain specific industrial applications. The annual consumption of methanol in Uruguay is approximately 19 GWh/a. This volume is primarily allocated to the chemical, pharmaceutical, and laboratory industries. Since national production is insufficient to meet this demand, the country relies on imports, mainly from Argentina (Diario Cambio 2022).

Petroleum derivatives:

In 2023, Uruguay had a total production of 17,085 GWh/a (1,469 ktoe) of petroleum derivatives (Figure 13). In this year, the supply of petroleum derivatives in Uruguay was impacted by the La Teja refinery, which underwent a scheduled maintenance shutdown in September. As a result, the production of petroleum derivatives was 31% lower than the previous year, and imports increased by 140%, according to the National Energy Balance. This refinery, which is owned by ANCAP, is the only refinery in the country (Balance Energético Nacional Uruguay 2024).

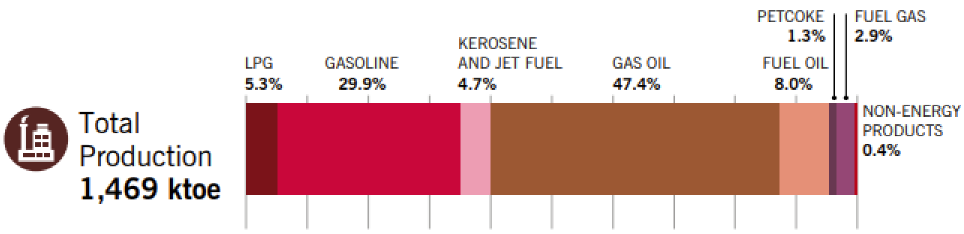


Figure 13. Production of petroleum derivatives in Uruguay in 2023 (Balance Energético Nacional Uruguay 2024)

Projected Production for the Future PtX Market in Uruguay:

The country has the potential to grow its hydrogen production to satisfy domestic market demands. The sectors anticipated to utilize green hydrogen include (Ministerio de Industria, Energía y Minería 2023a):

- Shipping, which is expected to make use of e-methanol and green ammonia
- Fertilizers, which are expected to use green ammonia.
- Land transportation, which is expected to use of hydrogen.

The expected quantities produced in the country for the domestic market of green ammonia, e-methanol and green hydrogen are shown in Table 3. Additionally, the projected production for export purposes of green hydrogen and derivatives is presented in Table 4:

Table 3. Expected production for domestic use of hydrogen, ammonia, synthetic fuels and fertilizers in Uruguay in 2030 and 2040 (Universidad Católica del Uruguay 2024)

Product	2030 (GWh/a)	2040 (GWh/a)
Green hydrogen	367	3,566
Green ammonia	165	2,785
Synthetic fuels (e-kerosene)	48	204
Fertilizers (e.g., urea)	133	598

Table 4. Expected production for export purposes of hydrogen, ammonia, synthetic fuels and fertilizers in Uruguay in 2030 and 2040 (Universidad Católica del Uruguay 2024)

Product	2030 (GWh/a)	2040 (GWh/a)
Green hydrogen	-	10,699
Green Ammonia	-	522
Maritime (e-methanol)	257	2,614
Jet Fuel (e-kerosene)	611	7,483

Furthermore, in (Universidad Católica del Uruguay 2024) is indicated that total hydrogen production (both for domestic use and exports) is expected to reach 2,033 GWh/a by 2030 and 32,563 GWh/a by 2040. By 2040, a projected electrolysis capacity of 9 GW will be required (IEA 2024).

Further characteristics of PtX market in Uruguay

Ammonia:
Currently, there is no infrastructure for ammonia transport in the country, which means there are high initial CAPEX requirements for the implementation of ammonia projects. Figure 14 indicates the potential areas where ammonia projects could be placed (Universidad Católica del Uruguay 2024). The main areas with development potential by 2030 are the West Coast and the East Coastal Zone. In the central part of the country, potential areas can also be observed, with access to active railways. These last two regions require the development of new ports.

Methanol and synthetic fuels:
Due to Uruguay's potential for biogenic CO_2, the green methanol and synthetic fuel market could be particularly attractive for external markets. According to Figure 15, important areas with project development potential by 2030 consist of cities in the western part of the country, including Paysandú, Fray Bentos, and Nueva Palmira, along with Pueblo Centenario and Tacuarembó, which are situated in the central region. By 2040, other notable areas include the eastern part of the country, such as Rivera, Lavalleja, and Rocha (Universidad Católica del Uruguay 2024).

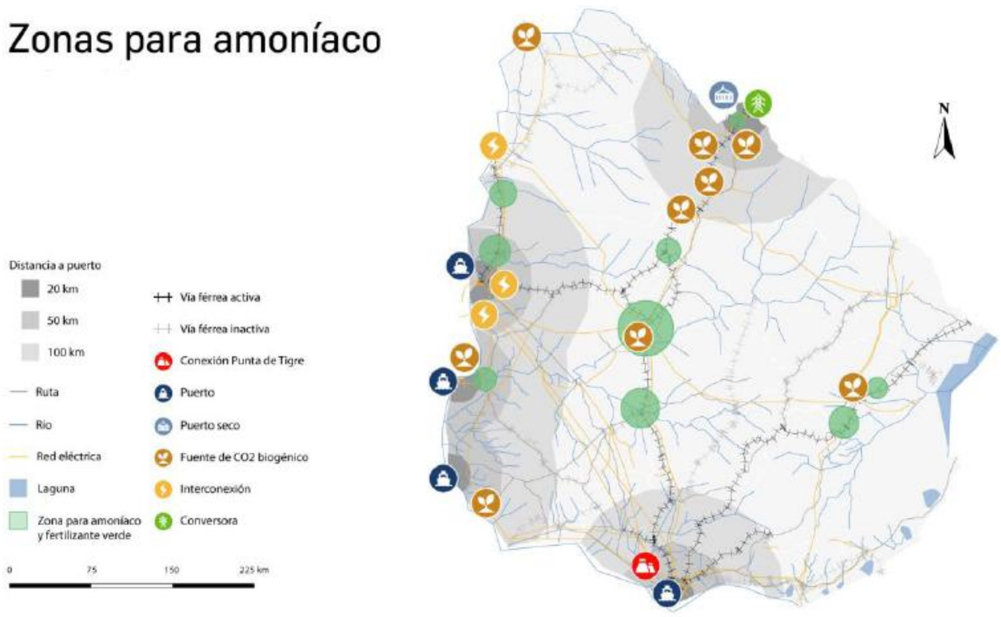


Figure 14. Potential areas for ammonia projects in Uruguay (Universidad Católica del Uruguay 2024).

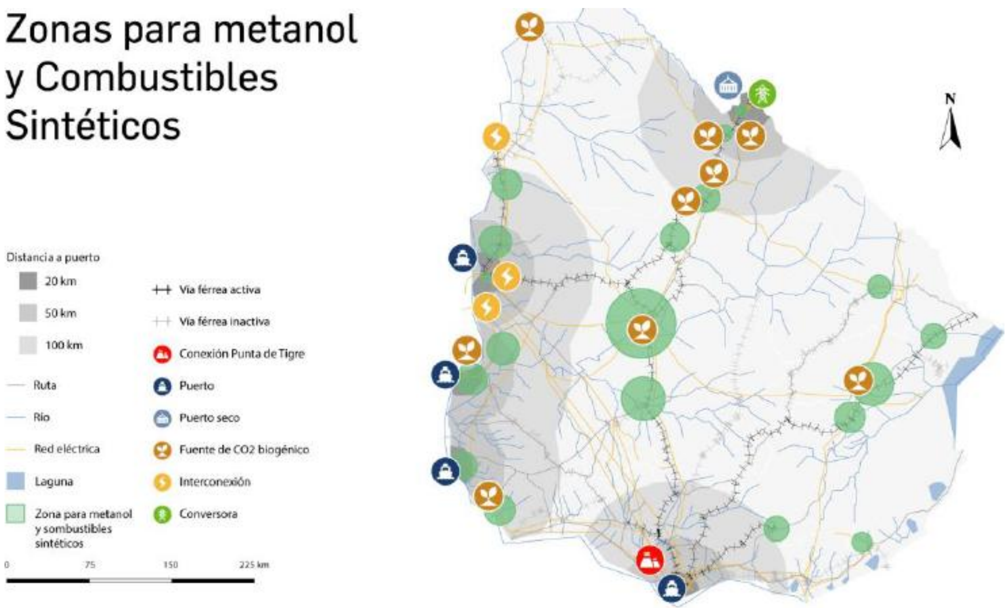


Figure 15. Potential areas for methanol and synthetic fuels projects in Uruguay (Universidad Católica del Uruguay 2024)

Countries targeted for export:

- European Union countries: the RePowerEU package announces a hydrogen use accelerator for European countries. According to the European Commission, 333 TWh/a of hydrogen is expected to be imported by 2030 (GHIC 2025).

- **Germany:** with Germany's new green hydrogen import strategy, a substantial share of the country's hydrogen demand will be met through imports. The estimated demand for hydrogen and its derivatives in Germany is projected to be between 95 and 130 TWh/a by 2030, with 50 to 70% (45 to 90 TWh/a) expected to be imported. This positions Germany as one of the largest hydrogen importers globally. (Bundesministerium für Wirtschaft und Klimaschutz 2024).
- **Japan:** Japan's capacity for domestic hydrogen production is significantly limited due to a lack of suitable land, leading the country to become a net importer of clean hydrogen. According to its hydrogen strategy, Japan aims for a hydrogen demand of 100 TWh/a (3 Mt/a) by 2030 and 667 TWh/a by 2050 (Sieler et al. 2021). According to Figure 16 in (International Energy Agency 2021), 64% of that hydrogen demand will need to be imported. In the scenarios outlined by the IEA, Japan is expected to consume 17 TWh/a of ammonia as fuel for co-firing in coal plants and maritime transport, along with 23 TWh/a hydrogen as feedstock for the chemical industry by 2030.
- **South Korea:** South Korea plans to import approximately 67 TWh/a of clean hydrogen by 2030 and ca. 767 TWh/a of clean hydrogen by 2050 (GHIC 2025).
- **China:** China is expected to be the world largest clean hydrogen importer, requiring 433 TWh/a of hydrogen by 2030 (HydrogenCentral 2025).

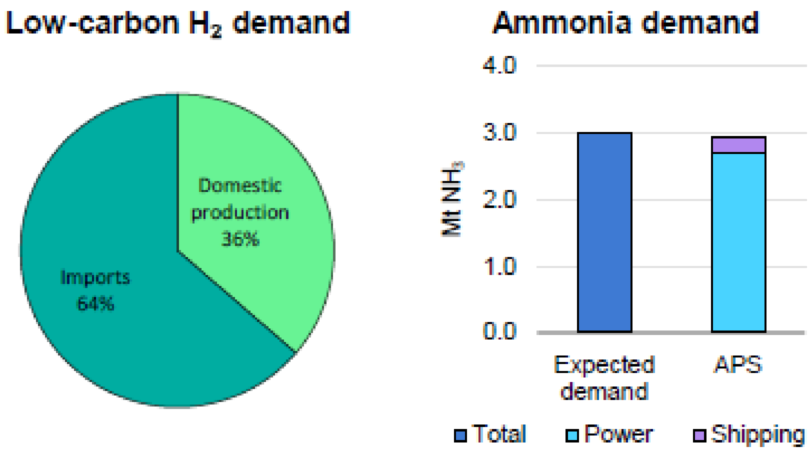


Figure 16: Low-carbon hydrogen demand in Japan by 2030 (International Energy Agency 2021).

3.2.3 Benchmarking resources and costs in Uruguay against other countries

Uruguay is positioning itself as a competitive player in the global landscape of green hydrogen production, capitalizing on its robust foundation in renewable energy. It distinguishes itself among the leading countries with substantial potential for producing low-cost green hydrogen, alongside Chile, Australia, Argentina, Venezuela, Mauritania, and Brazil. This chapter conducts a benchmarking analysis of Uruguay against other countries in terms of resources and costs based on (Pfennig et al. 2020),

Figure 17 illustrates global coastal locations, highlighting green hydrogen production costs ranked from lowest to highest **by 2050**. The most economic costs are associated with regions that have favorable wind and solar conditions. For instance, both Chile and Argentina benefit from excellent wind resources, with production costs for liquid green hydrogen ranging from 60 to 70 EUR/MWh and a production capacity of 360 TWh/a from wind sources. Chile also benefits from strong solar resources, with costs between 80 and 90 EUR/MWh and a maximum production capacity of 1,572 TWh/a.

Other countries, such as Venezuela and Mauritania, provide favorable hybrid (PV-wind) locations that facilitate low hydrogen costs ranging from 67 to 80 EUR/MWh, with production capacities of 269 TWh/for Venezuela and 986 TWh/a for Mauritania. Brazil and Australia also feature favorable hybrid sites for producing low-cost hydrogen, with costs between 82 and 87 EUR/MWh and production capacities of 227 TWh/a and 982 TWh/a, respectively.

In Uruguay, the costs for green hydrogen range from 87 to 92 EUR/MWh for coastal hybrid sites, which have a production capacity of 15 TWh/a, and from 99 to 105 EUR/MWh for coastal wind sites with a capacity of 4 TWh/a. Furthermore, Uruguay has been recognized as a potential leader in low-cost green hydrogen production at inland sites, where hybrid locations could reach a maximum production capacity of 928 TWh/a, with estimated costs of 92 EUR/MWh, further solidifying Uruguay's capabilities in low-cost green hydrogen production (Pfennig et al. 2020)

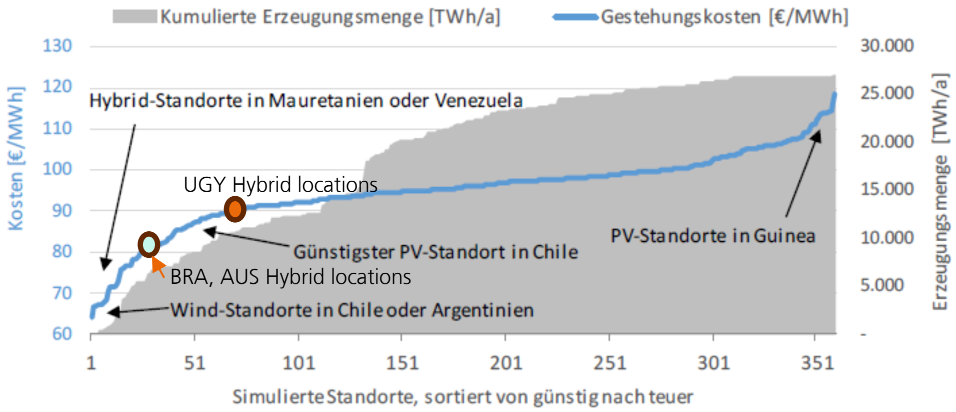


Figure 17. Production costs and cumulative production amount of globally studied coastal sites to produce liquid hydrogen using low-temperature PEM electrolysers in 2050 (Pfennig et al. 2020).

3.3 Inventory 1: planned projects and actors in the country

3.3.1 Projects

Kahiros

The Kahirós Project is a joint development by the companies *Ventus, Fraylog*, and *Hyundai-Fidocar* to install the first pilot in Uruguay that uses Green Hydrogen for consumption by heavy-duty trucks, providing services to the forestry supply chain, particularly for the client Montes del Plata. It will be located in Fray Bentos, an area chosen for its proximity to the forestry demand center and its existing logistical and industrial use.

The project has the support of Montes del Plata due to its strategic importance for the future of zero-emission transportation, ensuring demand for the project over the next 10 years and contributing to knowledge development. For hydrogen production, a compact modular plant is planned, consisting of a 2 MW electrolyser, with an estimated annual production of 76,700 kg of H2 (~2,556 MWh/a). The green H2 production process will be generated through the electrolysis of groundwater, using energy from a 3.9 MW Photovoltaic Solar Park that will be installed on site (Andrea Janics 2008).

Paysandú green hydrogen project:

ANCAP has made significant progress in projects within the strategic agenda in Uruguay, particularly in energy transition projects. In this context, HIF, one of the leading producers of green fuels globally, has been selected to produce green methanol, utilizing biogenic CO_2 captured from the ALUR biofuels plant in Paysandú. The installation of approximately 2 GW of solar and wind farms and an electrolyser capacity of 1 GW is planned. This setup will produce 100,000 t/a (~3.33 TWh/a) of hydrogen, which will be combined with 710,000 t/a of CO2 (145,000 tons captured from ALUR's sources and the remainder produced by HIF from biomass waste) to generate 480,000 t/a of methanol (~3 TWh/a). The methanol will then be sent to a MtG (methanol to gasoline) plant to produce 180,000 t/a of gasoline (~2.3 TWh/a) (ANCAP 2023).

Tambor green hydrogen hub project

The Tambor Green Hydrogen Hub is a project launched by ENERTRAG, initially featuring renewable energy facilities (wind and solar photovoltaic) with a capacity of 350 MW and an on-site electrolyser capable of producing 15,000 tons of hydrogen (~500 GWh/a), which will be converted into e-methanol. This project is being planned and developed in partnership with the Uruguayan project developer SEG Ingeniería (ENERTRAG 2025).

Until early 2025, the Tambor project is undergoing environmental assessment by the Ministry of the Environment. Technical observers such as Udelar have pointed out deficiencies in the project communication, particularly in hydrogeological aspects and water use. The project must go through several stages (disclosure of the Impact Study, public hearing, final technical report, and ministerial resolution), in accordance with the national environmental assessment procedure (Ministerio de Medio Ambiente 2025), (Veroslavsky et al. 2024).

In the context of the Tambor project, environmental organizations have expressed concerns about the potential impacts on the Guaraní Aquifer System and have called for greater participation in the project's environmental assessment process. Frameworks such as the “Plan de Gestión Integrada del Sistema Acuífero Guaraní (PGISAG)” should also be taken into account in such environmental evaluations (Qassim 2025), (Ministerio de Medio Ambiente 2023).

H2U Offshore ANCAP:

The H2U Offshore initiative is a strategic program led by ANCAP, aiming to harness the country’s offshore wind potential for large-scale green hydrogen production. This initiative is part of Uruguay’s broader commitment to achieving carbon neutrality by 2050 (International Trade Administration 2021). The H2U Offshore program aims to develop offshore wind farms to produce green hydrogen and its derivatives, including ammonia, for export. The program is organized around international tenders, known as "rounds," allowing private companies to bid to develop these offshore areas at their own expense and risk. The total investment for the H2U Offshore project is estimated to be between USD 1 billion and USD 3 billion (International Trade Administration 2021).

H24U Project:

The H24U project is a collaboration between CIR and SACEEM, aimed at establishing Uruguay's first commercial-scale green hydrogen production and utilization system, specifically targeting the decarbonization of the heavy freight transport sector. An investment of approximately USD 43.5 million is planned for the development and construction of two plants: one photovoltaic and the other for Green Hydrogen production, along with a fleet of trucks dedicated to the forestry supply chain. This includes USD 10 million in non-reimbursable funding provided over 10 years by Uruguay's Green Hydrogen Sectorial Fund, which is managed by the Ministry of Industry, Energy and Mining (MIEM), the Technological Laboratory of Uruguay (LATU), and the National Agency for Research and Innovation (ANII) (Estratégica 2023). With the change in government, the project is currently on hold; updates are expected in the coming weeks.

3.3.2 Existing programs and initiatives

H2U is a program that outlines the current work priorities for the development of green hydrogen and its derivatives in an inter-institutional framework in Uruguay. The program consists of six thematic areas: H2U Innovation, H2U Investment, H2U Infrastructure, H2U Regulation, H2U Offshore, and H2U Communications and capacity building (Ministerio de Industria, Energía y Minería 2022).

- H2U Innovation: Innovation and research in green hydrogen and its derivatives will be supported through various mechanisms, e.g., Hydrogen Sector Fund for innovative and research projects. Both private and public companies will play a key role in generating ideas and executing projects. The coordinating institutions will include the Ministry of Industry, Energy and Mining (MIEM), the National Agency for Research and Innovation (ANII), the Technological Laboratory of Uruguay (LATU), and the academic sector (Ministerio de Industria, Energía y Minería 2022),
- H2U Investment: here it is aimed to facilitate investments in green hydrogen projects and derivatives in Uruguay by addressing tax incentives, permits, green hydrogen certification design, special electricity tariffs, and international cooperation. Responsible: Ministry of Industry, Energy and Mining (MIEM), Ministry of Economy and Finance (MEF), Ministry of Environment (MA), Ministry of Foreign Affairs (MRREE), Office of Planning and Budget (OPP), and Uruguay XXI (Ministerio de Industria, Energía y Minería 2022),
- H2U Infrastructure aims to evaluate further development in the infrastructure e.g., gas pipelines, transmission lines. Responsible: MIEM, Ministry of Transport and Public Work (MTOP), National Ports Administration (ANP), National Administration of Fuels, Alcohol and Portland (ANCAP), National Administration of Power Plants and Electric Transmissions (UTE) (Ministerio de Industria, Energía y Minería 2022),
- H2U Regulation aims to establish new regulations concerning hydrogen (e.g., production, storage, safety regulations) and to advance regulations related to land use. The responsible institutions include MIEM, the Energy and Water Services Regulatory Unit (URSEA), MVOT, MTOP, and MA (Ministerio de Industria, Energía y Minería 2022),
- H2U Offshore: this component focuses on studying the potential of offshore energy. Responsible institutions: MIEM and ANCAP (Ministerio de Industria, Energía y Minería 2022),
- H2U Communications and capacity building aims to implement national communication and citizen participation plans, along with the regular and transparent dissemination of progress updates (Ministerio de Industria, Energía y Minería 2022).

Furthermore, the ANII, in collaboration with MIEM and LATU, has launched specific funding mechanisms to support hydrogen R&D. As previously mentioned, the Green Hydrogen Sector Fund has already funded Uruguay’s first pilot project (”H24U”), which integrates R&D in electrolysis technology, solar integration, logistics, and hydrogen mobility (LATU 2022) (ANII 2023). Additionally, hydrogen-related proposals have received support through broader instruments like the Energy Sector Fund, reinforcing cross-cutting research in renewable energy, materials science, and process optimization (Ministerio de Industria, Energía y Minería 2024c).

At the international level, Uruguay is actively participating in cooperation programs with the European Union, Germany (BMFTR, BMWE) (Ministerio de Industria, Energía y Minería 2024c), and multilateral institutions (e.g., IDB, UNIDO, GIZ) (UNIDO 2021), (Federal Ministry for Economic Affairs and Climate Action 2024) (International Development Bank 2023). These initiatives have helped enhance research capacities through training, feasibility studies, and expert exchanges. However, further integration into global research networks is necessary to increase the country's visibility and access to frontier technologies in areas such as offshore hydrogen production, hydrogen storage, and synthetic fuel synthesis.

3.3.3 Actors and their roles (universities, companies, ministries, ANII)

In Uruguay's emerging green hydrogen market, various actors play pivotal roles in driving development and innovation. These stakeholders include public energy companies, private investors, research institutions, and government agencies, each contributing distinctive expertise and resources to advance hydrogen initiatives. Public entities like UTE and ANCAP facilitate infrastructure development and project financing, while private companies explore technological advancements and market opportunities. The collaborative efforts among these diverse actors are essential for creating a robust green hydrogen ecosystem. A comprehensive overview of these key players and their respective roles can be found in the table included as an Annex of this report.

3.4 Inventory 2: capacity building and research

3.4.1 Analysis of the current research and development situation

Uruguay's current research and development (R&D) landscape in green hydrogen is characterized by early-stage institutional engagement, selective public funding instruments, and growing participation in international cooperation projects. Even though some groups in academia have remarkable experience on the subject, recent years have seen key advancements that lay the foundation for scaling up R&D activities aligned with the national hydrogen roadmap. The institutions and universities engaged in hydrogen-related research are listed:

- Universidad de la República (UdelaR), which has established research lines in electrochemical technologies, catalysis, renewable energy integration, and carbon valorization. Research groups within the Facultad de Química, Facultad de Ingeniería, and Centro Universitario Regional del Este (CURE) have initiated studies related to water electrolysis, Power-to-X (PtX) pathways, and the capture and utilization of CO_2 from biomass sources (Universidad de la República Uruguay 2025b).
- Instituto Tecnológico de la Energía (IET) and the Centro de Innovación en Ingeniería (CII) are advancing applied research in renewable energy systems integration and hydrogen production technologies (Universidad de la República Uruguay 2025a), .
- Other institutions are also important players for the R&D environment as to mention, Universidad Tecnológica (UTEC) and Instituto de Investigaciones Biológicas "Clemente Estable" (IIBCE), through the "*RedH2Uy*"; Universidad de Montevideo (UM) particularly through the "*Centro de Innovación en Organización Industrial (CINOI)*" and Universidad Católica del Uruguay (UCU), through its "*Observatorio de Energía y Desarrollo Sustentable*", (Universidad de Montevideo) (UTEC 2025a), (Ministerio de Industria, Energía y Minería 2024c).
- UTE: CAF, the development bank for Latin America and the Caribbean, signed a technical cooperation agreement with UTE, in which USD 100,000 is allocated for technical studies on environmental, technological, financial, and regulatory issues regarding the production, storage, and transport of green hydrogen (CAF 2023b)

A detailed list of R&D projects in Uruguay in the context of green hydrogen and PtX can be found as an annex of this report.

3.4.2 Analysis of the current capacity building

Capacity Building

Capacity building in Uruguay's green hydrogen sector is progressing steadily, with efforts primarily concentrated on strengthening technical education, enhancing institutional capabilities, and addressing knowledge gaps in key segments of the hydrogen value chain. While still in a formative phase, several initiatives have been launched to lay the groundwork for developing a skilled workforce and promoting long-term human capital development aligned with the roadmap's goals.

UdelaR, and UTEC are beginning to incorporate renewable energy and hydrogen-related content into existing engineering and science programs. Although no specific undergraduate or postgraduate degree in hydrogen technologies exists yet, various faculties—particularly in chemistry, physics, mechanical engineering, and environmental science—are integrating hydrogen-related modules into their curricula (Universidad de la República

Uruguay 2025d, 2025c; Gallardo et al. 2017). In terms of technical training, UTEC has launched initiatives in renewable energy systems and electrical infrastructure, which may be expanded in the future to include hydrogen-related competencies (UNIVERSIDAD TECNOLÓGICA 2025). In parallel, several short courses have been delivered to provide professionals and technicians with basic knowledge on green hydrogen and PtX technologies, including overviews of the full value chain and associated regulatory frameworks (AHK Uruguay 2024). However, structured programs for technicians focused specifically on electrolyser operation, hydrogen logistics, or PtX handling are still lacking. Addressing this skills gap is particularly relevant for supporting the deployment and operation of upcoming pilot and commercial-scale hydrogen facilities.

International cooperation has also played a key role in knowledge transfer and capacity enhancement. Uruguay has participated in bilateral training programs with Germany and the European Union, including workshops on hydrogen safety standards, regulatory frameworks, and technology transfer. Technical missions and joint seminars have facilitated early-stage learning and institutional coordination but will need to evolve into more structured and long-term training programs, ideally co-developed with industry partners (World Economic Forum 2024).

Educational programs for technicians
Uruguay offers educational programs for technicians that focus on Renewable Energy and Electrical Systems Management. These programs cover the following key areas:

- Power Systems and Industrial Electrical Installations: Training in the design and management of electrical systems used in industrial settings.
- Environmental Emissions Control and Auditing Training: Instruction on monitoring and controlling emissions to comply with environmental regulations.
- Design, Installation, and Maintenance of Electrical Infrastructure: Skills for creating and sustaining the electrical systems necessary for energy production and distribution.
- Maintenance and Repair of Mechanical-Electrical Systems: Training in the upkeep of systems that combine mechanical and electrical components.
- Maintenance of Photovoltaic and Wind Systems: Specialized courses on ensuring the efficient operation of solar and wind energy systems.
- Applied Biotechnology: Focus on the use of biotechnology in industrial processes and energy applications.
- Analytical, Organic, and Industrial Chemistry: Instruction in various chemistry disciplines relevant to developing materials and processes in energy systems.
- Mechanical Design and Maintenance: Training in the design and upkeep of mechanical systems within the energy sector.

However, there is currently no specific program focused on hydrogen and its derivatives.

Undergraduate programs:
Undergraduate programs in Uruguay offer a diverse range of specializations focused on renewable energy and sustainability. These programs include specializations in solar and wind energy, as well as applied biotechnology for industrial and energy purposes. Students receive training in critical areas such as environmental emissions control, water management, and the design and maintenance of electrical infrastructure. Additionally, there is a strong emphasis on practical skills, including automation, instrumentation, and project design. The curriculum is designed to prepare graduates for key roles in the growing fields of hydrogen systems and clean energy, ensuring they are well-equipped to address the challenges of the energy transition.

3.5 National strategy objectives and their priorities

This chapter addresses the goals and priorities related to green hydrogen and PtX in Uruguay, as outlined in the national roadmap. The proposed roadmap strategy aims to position Uruguay as a leader in the green hydrogen sector, with the potential to generate approximately USD 1.9 billion in annual revenues by 2040 (Ministerio de Industria, Energía y Minería 2023a). This revenue will primarily stem from the export of synthetic fuels and hydrogen, providing a significant boost to the national economy. Moreover, the development of a hydrogen industry is anticipated to create more than 30,000 direct, skilled jobs across various sectors, thereby enhancing employment opportunities and workforce capabilities (Ministerio de Industria, Energía y Minería 2023a).

3.5.1 Short-term, mid-term and long-term goals

This roadmap aims to develop a domestic and an export market for the years 2025 (short-term), 2030 (mid-term), and 2040 (long-term), with priority given to the production of e-methanol, e-fuels, fertilizers, H_2 utilization in Direct Reduced Iron (DRI) processes, and heavy-duty transport. The Figure 18 outlines the expected objectives mentioned in the National Roadmap (Ministerio de Industria, Energía y Minería and H2U 2024):

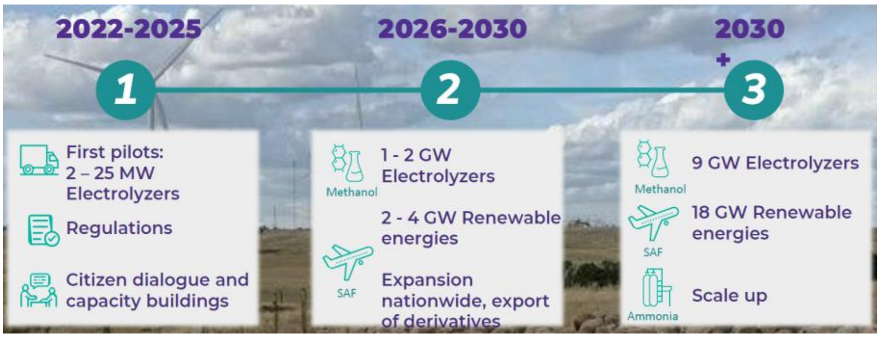


Figure 18. Phases of the green hydrogen roadmap in Uruguay according to (Ministerio de Industria, Energía y Minería and H2U 2024)

Uruguay's national roadmap for green hydrogen production outlines estimated production costs (Ministerio de Industria, Energía y Minería and H2U 2024), (Ministerio de Industria, Energía y Minería 2023a). Figure 19 projects the levelized cost of hydrogen (LCOH) from 2025 to 2050, with estimates of 1.20-1.40 USD/kg (approximately 41-47 EUR/MWh) in the western region and 1.30-1.50 USD/kg (about 44-51 EUR/MWh) in the eastern region for projects over 500 MW. For offshore projects, a LCOH of 1.70-1.90 USD/kg (around 58-64 EUR/MWh) is expected by 2030. The roadmap also highlights an estimated LCOH of 1.50-2.40 USD/kg (approximately 51-81 EUR/MWh) by 2025. As for derivatives, production costs by 2030 for green e-methanol and e-jet fuel could reach USD 465/t (~83 EUR/MWh) and USD 1,205/t (~113 EUR/MWh), respectively, considering biogenic CO_2 sources (Ministerio de Industria, Energía y Minería 2023a). In the context of international green hydrogen production costs in Figure 20, Uruguay is set to be a net exporter and is projected to rank as the second-lowest exporter in terms of LCOH.

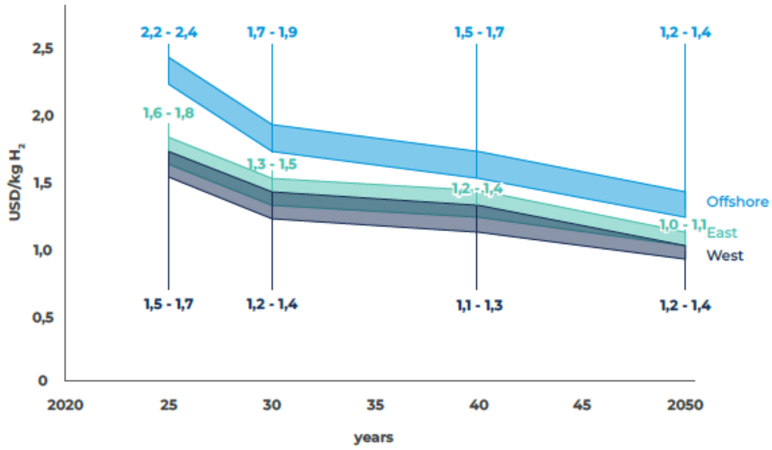


Figure 19. LCOH in Uruguay from 2025 until 2050. Assumptions: a minimum daily production of 250 tH_2. It includes energy and electrolyser CAPEX & OPEX, storage, transport or transmission add approx. 0.3-0.5 USD/kgH2 (Ministerio de Industria, Energía y Minería 2023a).

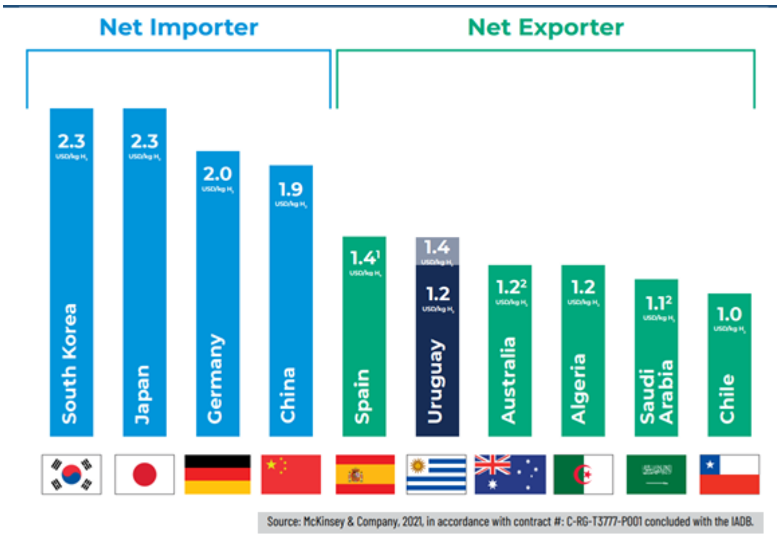


Figure 20. Comparison of LCOH. 1) benchmark taken from HyDeal announcement, excludes transport and distribution costs. 2). Benchmark taken from the Hydrogen Council, excludes transport and distribution costs (Ministerio de Industria, Energía y Minería 2023a)

3.5.2 Priorization of research focus areas

Uruguay's national green hydrogen roadmap emphasizes research in the production of green hydrogen and its derivatives. It also addresses the development of port infrastructure and the establishment of new regulations governing the production, storage, and transportation of green hydrogen. Additionally, the roadmap includes initiatives for developing training and educational programs to address potential labor and knowledge gaps (Ministerio de Industria, Energía y Minería 2023a, 2022).

- Production of green hydrogen and its derivatives: special focus on the research and development of projects to produce e-methanol, synthetic fuels (e-Fuels) and use of green hydrogen for iron processing (DRI)

- **Offshore wind potential:** long-term research aimed at evaluating the feasibility of using offshore wind energy to produce green hydrogen,
- **Regulations:** The development of new regulations for the production, storage, and transportation of green hydrogen, along with a focus on establishing clear and safety standards,
- **Capacity building and training:** The development of new educational and training programs focused on renewable energy topics, specifically technology related to hydrogen and its derivatives.

4 Analysis of current activities and relevant actors according to the methodology: SWOT Analysis

This section presents a strategic analysis of Uruguay's current landscape in relation to green hydrogen research, development, and innovation. Building on the data and institutional mapping conducted in previous chapters, the analysis applies a **SWOT (Strengths, Weaknesses, Opportunities, Threats)** framework to evaluate the national context and identify key enablers and barriers for the implementation of the green hydrogen R&D roadmap. The assessment focuses on both **internal factors**—such as institutional capacity, research infrastructure, funding mechanisms, and regulatory maturity—and **external factors**, including international market trends, technological developments, cooperation opportunities, and geopolitical risks.

The purpose of this analysis is to provide an evidence-based foundation for decision-making, highlighting priority areas for investment, coordination, and policy reform. It also supports the identification of critical actors and activities that can contribute to advancing Uruguay's positioning as a competitive and sustainable green hydrogen player at regional and global levels. The SWOT methodology integrates inputs from interviews with key stakeholders, a review of national and international documents. The following subsections outline the analytical process and present the key findings of the SWOT analysis.

4.1 Introduction to the topic and objective of the analysis

In order to develop a coherent and realistic R&D roadmap for green hydrogen in Uruguay, it is essential to assess the current landscape of activities, actors, and systemic conditions influencing the sector. A SWOT analysis—identifying internal **Strengths** and **Weaknesses**, as well as external **Opportunities** and **Threats**—provides a structured methodology to examine these dimensions and to inform strategic decisions. This analysis focuses on Uruguay's present institutional, technical, and regulatory ecosystem, evaluating how existing capacities, ongoing initiatives, and identified gaps may affect the deployment and scaling of hydrogen technologies. The objective is twofold:

1. **To map the readiness and limitations** of Uruguay's research and innovation ecosystem, including public and private stakeholders involved in hydrogen-related activities.
2. **To identify key leverage points and risks** that should be addressed to ensure the effective implementation of the national green hydrogen roadmap.

The SWOT analysis incorporates findings from stakeholder interviews, desk research, and project-level insights provided by national and international partners. It serves as a diagnostic tool to guide the prioritization of research areas, capacity-building needs, policy adjustments, and cooperation strategies that align with Uruguay's short-, mid-, and long-term goals.

By systematically evaluating internal and external factors, this analysis supports evidence-based planning and strengthens the alignment between national capacities and international market dynamics in the evolving hydrogen economy.

4.2 Approach to conducting the SWOT analysis (including interviews)

The SWOT analysis presented in this section was developed through a **multi-method approach**, combining qualitative and quantitative inputs to capture a comprehensive view of the status and prospects of Uruguay's green hydrogen research and innovation ecosystem. The methodology consisted of three main components:

i. **Document and Literature Review:** A thorough review of national and international reports, legal frameworks, policy documents, and sectoral strategies was conducted to identify existing institutional mandates, research programs, regulatory instruments, and market dynamics relevant to green hydrogen in Uruguay. Key sources included the H2U National Roadmap (Ministerio de Industria, Energía y Minería 2023a), sectoral studies, and international benchmarking reports such as (IEA 2024; Ministry of Economic Affairs and Climate Policy of the Netherlands 2024; Pfennig et al. 2020; Universidad Católica del Uruguay 2024; Vukasovic and Messina 2024b),

ii. **Stakeholder Interviews:** A series of **semi-structured interviews** were carried out with key stakeholders between May and October 2024. Interviews focused on institutional roles, technical capabilities, regulatory challenges, financing mechanisms, and strategic priorities for hydrogen-related R&D. Participants included representatives from:

    a. Government agencies (MIEM, ANII, UTE, ANCAP)
    b. Academic and research institutions (UdelaR, UTEC, UM, UCU, IIBCE)
    c. Private sector actors and business chambers (AHK)
    d. Political stakeholders (BROU, BCU)

iii. **Expert Feedback and Iterative Validation:** Preliminary SWOT elements were discussed in joint sessions with national and international project partners to refine the analysis. This iterative process ensured alignment with both domestic policy priorities and global hydrogen market trends.

The resulting SWOT framework reflects a cross-cutting and participatory diagnosis of the conditions shaping Uruguay's ability to position itself as a regional knowledge hub and technology developer in the emerging green hydrogen sector. This evidence-based approach allows for the identification of strategic actions to strengthen internal capacities and leverage external opportunities in line with the roadmap's objectives.

4.3 Identification of internal strengths

With over 92% of its energy matrix derived from renewable sources, Uruguay is nearly fully electrified, positioning itself as a competitive player in the global green hydrogen market. The strong synergy among hydropower, solar energy (with capacities ranging from 60 GW to 135 GW), and wind resources (with onshore capacities between 30 GW and 50 GW and offshore capacities of up to 275 GW) enhances its transition to green hydrogen. According to section 3.2.3, Uruguay's estimated production capacity for green hydrogen by 2050 is projected to reach 15 TWh/a, with production costs ranging from 87 to 92 EUR/MWh for coastal hybrid sites. Projections in section 3.2.2 indicate that by 2040, Uruguay could generate a total of approximately 32,563 GWh/a (or 977 kt/a of H2), which includes 2,614 GWh/a of methanol production, highlighting its potential for cost-effective production alongside countries such as Chile, Argentina, and

Brazil, which also compete in the hydrogen market with lower production costs. Interviewees consistently recognized the renewable-based energy matrix as "Uruguay's biggest international calling card." Several highlighted that this high penetration of renewables gives Uruguay reputational credibility and lowers entry barriers for green hydrogen investors.

Additionally, as noted in section 3.1.4, Uruguay benefits from significant biogenic CO_2 availability, totaling 9.3 Mt/a. This CO_2 represents 82% of total emissions from various industries, including forestry and agriculture, enabling the country to produce the estimated 2,614 GWh/a of methanol by 2040. Looking ahead, this total production capacity is expected to not only meet the current hydrogen demand of around 2,584 GWh/year (or 78 kt/a of H_2) but also position Uruguay as a potential exporter to international markets such as the European Union, Japan, and South Korea, where the demand for sustainable energy solutions is rapidly increasing. Stakeholders from industry and academia emphasized the strategic value of combining hydrogen with biogenic CO_2, often describing e-methanol as "the most realistic export product in the short-to-medium term." Others noted that this coupling helps Uruguay stand out from regional competitors who do not have the same biomass/CO_2 profile.

The Uruguayan port system further strengthens this position, showcasing robust logistical capabilities with the ability to handle approximately 20 million tons of cargo annually. The Port of Montevideo plays a crucial role by managing around 17 million tons per year, reinforcing Uruguay's status as a vital maritime hub in the Southern Cone for exports. This efficiency enhances regional connectivity and operational resilience in addressing logistical challenges.

Moreover, Uruguay's strong regulatory framework and environmental laws significantly bolster its green hydrogen sector. The requirement for Environmental Impact Assessments (EIAs) for large projects, including hydrogen plants, ensures thorough evaluation and mitigation of potential environmental impacts, promoting sustainable practices. Stringent water usage regulations safeguard essential water resources; Uruguay currently has approximately 92,000 million m³/a of water available. In 2022, authorized water uses by DINAGUA across the country amounted to 4,400 million m³, representing less than 5% of total availability. Notably, the additional water requirements for green hydrogen production are estimated to account for less than 1% of total water demand, allowing the sector to grow sustainably without overexploiting resources.

Interviewees from the public sector repeatedly emphasized that Uruguay's reputation for robust environmental governance is "one of its most distinct competitive advantages" in attracting European partners. At the same time, private actors acknowledged that strict Environmental Impact Assessments (EIAs) and water controls create predictability and reduce risks, even if they may slightly delay project timelines. Land use and social safeguards encourage public participation and community engagement in project planning, while the establishment of a dedicated Ministry of Environment emphasizes Uruguay's commitment to rigorous environmental oversight. Together, these factors create a stable and transparent regulatory environment that attracts investment and facilitates the responsible growth of the green hydrogen industry.

Finally, Uruguay's substantial expertise in renewable energy generation is enhanced by a robust governmental commitment to advancing in the green hydrogen sector. Initiatives such as the H2U program, along with the MoU signed with the European Union, foster coordinated governance among various governmental bodies. These efforts streamline decision-making processes and offer clear regulatory guidance, further reinforcing Uruguay's position in the green hydrogen landscape. Multiple interviewees, especially from academia and government, highlighted that the H2U program has been effective in aligning actors around hydrogen strategy. They described it as "a symbol of policy continuity and seriousness," which is rare in the Latin American context and attractive to foreign investors.

4.4 Identification of internal weaknesses

Despite its strengths, Uruguay faces several internal weaknesses that could hinder the development of its green hydrogen sector. A significant challenge is the limited availability of skilled workers and capacity building programs concerning the hydrogen technologies and market. There is a noticeable gap in expertise, particularly in key areas such as operating electrolysers, managing hydrogen logistics, and handling synthetic fuels. This shortage of specialized personnel may lead to operational delays and inefficiencies. According to section 3.5, to meet the projected demands of the green hydrogen industry by 2040, Uruguay will need a skilled technical and professional workforce of between 30,000 and 35,000 individuals. This substantial demand for trained labor highlights a potential vulnerability in the sector, as the current workforce may not be sufficient to support such rapid growth. Without the necessary personnel, the development and scaling of hydrogen projects could face significant setbacks, limiting Uruguay's ability to fully capitalize on its green hydrogen opportunities. In the interviews, stakeholders consistently pointed out that current training opportunities are fragmented and too theoretical; several proposed early workforce programs, sector-specific training, and even embedding pilot plants inside universities to provide hands-on learning. Without these, scaling up hydrogen projects will face bottlenecks.

Moreover, Uruguay lacks adequate research infrastructure specifically for hydrogen technology. Presently, there are no large-scale facilities for testing electrolysers or demonstrating new hydrogen technologies, which are essential for advancing the sector. This infrastructure gap is further intensified by the scarcity of dedicated research institutions and laboratories focused on hydrogen-related studies and training. Consequently, the country encounters difficulties in developing a skilled workforce equipped with the expertise needed to operate and innovate in this emerging field. Without these crucial resources, Uruguay may struggle to keep pace with global advancements in hydrogen technology, ultimately hindering its capacity to leverage the opportunities within the green hydrogen market. Also, interviewees highlighted the absence of shared testing facilities and suggested national demonstration labs or university–industry pilot plants to validate electrolyser performance and synthetic fuels under local conditions.

Another significant weakness is the absence of comprehensive regulations tailored to hydrogen production, storage, and transport. The lack of clear regulatory frameworks can discourage private investment, as potential investors may be uncertain about the legal environment. Regulatory clarity, safety codes, and certification schemes were ranked as very relevant by most interviewees. Several asked for alignment with EU and international standards from the outset. Currently, hydrogen production relies on general industrial safety codes, which have not been adapted for hydrogen-specific applications. This reliance may introduce safety risks and operational confusion, particularly for new green hydrogen projects that use electrolysis. Furthermore, Uruguay's transport infrastructure for hydrogen is underdeveloped. While Article 237 of Law 20,075/2022 establishes a legal framework for pipeline easements, detailed regulations regarding materials, pressure, and safety standards are still needed.

The railway network, which includes 271 km of central railway and 1,121 km of active rail, also has 1,465 km of inactive network that could potentially be revitalized for hydrogen transport. Although there are international rail connections to Argentina and Brazil, such as Salto – Concordia and Rivera – Livramento, there are currently no active agreements in place to utilize these routes. The evaluation of these links is essential for enhancing Uruguay's logistical capabilities.

4.5 Identification of external opportunities

Uruguay is strategically positioned to seize substantial opportunities in the green hydrogen sector, driven by favorable conditions and evolving market dynamics. The country has the potential to produce approximately 32,563 GWh/year (or 977 kt/a of hydrogen) by 2040, establishing itself as a key player in both local and international markets. This production capacity will not only meet domestic demand but also facilitate exports to international markets.

Importantly, Uruguay can produce methanol for both domestic use and export, as it complies with the sustainability requirements outlined in the RED III, particularly regarding CO_2 source eligibility. Currently, Uruguay's abundant biogenic CO_2 sources align well with these stringent criteria, enhancing its export potential. Most interviewees viewed methanol pilot projects as a first-mover advantage, particularly when associated with biogenic CO_2 sources. They recommended that initial PtX pilots focus also on methanol and e-fuels. Moreover, the green hydrogen sector is projected to generate approximately USD 1.9 billion in annual revenues by 2040, underscoring the significant economic impact that this industry could have on the national economy.

A notable advantage for this sector is Uruguay's ample water resources, totaling around 92,000 million m^3/a. Currently, less than 5% of this resource is utilized, indicating a sustainable supply that can adequately support the additional water requirements for hydrogen production, estimated to account for less than 1% of total water demand. This ensures that the hydrogen sector can expand without depleting essential water resources, thereby fostering sustainable growth.

Furthermore, the ongoing development of hydrogen transport infrastructure presents a crucial opportunity. The legal framework established for pipeline easements under Article 237 of Law 20,075/2022 lays the groundwork for future hydrogen transport projects, encouraging investment in this area. The potential revitalization of inactive railway networks, combined with existing international rail connections to Argentina and Brazil, could enhance Uruguay’s logistical capabilities. This integration into regional logistics and energy corridors will facilitate the efficient transport and distribution of green hydrogen, broadening market access and fostering collaboration in the Cono-Sur Region.

4.6 Identification of threats

While external market conditions are favorable, Uruguay faces several significant challenges that must be addressed to fully capitalize on its hydrogen potential. The country is up against intense international competition, particularly from nations like Chile, Argentina, and Brazil, all of which have abundant renewable resources and are rapidly advancing their hydrogen sectors. For example, Chile and Argentina are projected to produce hydrogen at costs as low as 60 to 70 EUR/MWh in the long term, while Brazil has costs ranging from 82 to 87 EUR/MWh. This competitive pricing landscape underscores the urgency for Uruguay to enhance its own production efficiency, where future costs range from 87 to 92 EUR/MWh for coastal hybrid sites according to 3.2.3. Although hybrid locations in Uruguay could theoretically reach a maximum production capacity of 928 TWh/a with estimated costs of 92 EUR/MWh, these figures still fall short of the lower costs achieved by its competitors, presenting a significant challenge.

In addition to facing international competition, Uruguay must address logistical challenges related to the transportation and storage of hydrogen and its derivatives. The existing limitations in transport infrastructure, including railways and pipelines, present a significant hurdle. Although upgrades to port facilities and rail systems are underway, substantial additional investments – such as the USD 460 million allocated for the Port of Montevideo – are necessary to meet the logistical requirements for large-scale hydrogen exports. Specifically, the hydrogen transport infrastructure must be developed to match the projected production levels of 32,563 GWh/year (or 977 kt/a) by 2040, which will require efficient logistics to effectively support export markets.

While DINAGUA indicates that the additional water requirements for hydrogen production are estimated to account for less than 1% of total water demand, a significant concern arises from the growing controversy over the use of groundwater resources for this purpose. One of the proposed projects mentioned in 3.3.1 aims to extract between 500 and 700 m³/day (up to 21,000 m³/month) from the strategically important and limited Guaraní aquifer to produce green hydrogen and methanol. This plan has sparked hesitation among social organizations, scientists, and residents, who are advocating for independent studies to assess the sustainability of water usage. Furthermore, the project has faced criticism for inadequate community engagement. Some interviewees warned that social acceptance could become a critical bottleneck: surveys already show low awareness in local communities, and past conflicts around water use illustrate risks if engagement is not transparent and participatory. A survey conducted by the University of the Republic found that a majority of the local population is either unaware (45.2%) or only somewhat aware (34.6%) of the initiative, with only 20.2% having a clear understanding of the project, which is still under review by the Ministry of Environment (Díaz 2024) (Sede Tacuarembó et al. 2024).

Therefore, achieving comprehensive social acceptance for large-scale hydrogen projects is crucial. Addressing potential environmental impacts, such as increased water usage and land use changes, while ensuring robust community engagement and transparent environmental assessment processes will be essential. To mitigate potential resistance and foster a conducive investment climate, it is important to establish clear, participatory, and transparent regulatory and permitting procedures.

4.7 Mapping of Current Activities vs. Prioritization of Activities in the PtX Context

4.7.1 Results from the interviews

To better understand the challenges and opportunities within the green hydrogen and Power-to-X (PtX) value chain in Uruguay, stakeholders were asked to complete a questionnaire. This questionnaire aimed at identifying potential barriers across various aspects of the value chain, such as the distance between renewable energy generation sites and production facilities for green hydrogen. Participants addressed issues related to the transportation of gases like CO_2, the development of hydrogen infrastructure for downstream products, and the necessary competencies for PtX, including the availability of a skilled workforce, lab-scale training facilities, and expertise in the field. Additionally, the survey sought insights into the political and regulatory framework conditions for PtX in Uruguay.

Stakeholders rated the relevance of each question on a scale from 1 (not relevant) to 5 (very relevant), allowing for a quantitative assessment of these questions. They were also requested to provide information about their current activities within the PtX value chain and share their perspectives on the potential for producing green hydrogen and PtX products in the country. The responses were categorized into three groups: those deemed most **relevant** and a priority for Uruguay, with scores between 80 and 95 points; **intermediate relevant**, with scores ranging from 63 to 79 points; and those considered **not relevant**, with scores between 38 and 62 points. This classification facilitated the identification of areas that require greater attention and action in the development of the hydrogen sector in the country. According to the results, the respondents identified several key areas that need to be reviewed in Uruguay:

Relevant (80-95 points)	Intermediate (63 - 79 points)	Not relevant (38 - 62 points)
• In-Person and On-Site Capacity Building & Training Services • Business development support • Lack of comprehensive knowledge in PtX • Project development assistance • Collaborative R&D programs and infrastructure • Export infrastructure for PtX products at ports is missing	• Assistance in developing policies, regulations, and certification schemes for green hydrogen production • High costs associated with CO2 purification from industrial off-gases and direct air capture • Shortage of skilled workforce in general • Transport and Logistics Issues	• Political Support and Integration Challenges • High costs in seawater purification • Transport Challenges through pipeline transport of purified seawater is both difficult and expensive • Competing Water Needs: There is significant competition for water resources from drinking water, agriculture • Energy Demand Competition with residential and industrial sector

Figure 21. Prioritization of activities according to the interviews

4.7.2 Prioritized activities based on the results

In this chapter, key activities in Uruguay will be prioritized. This prioritization is based on the findings in Chapter 4.7.1 and should be regarded as essential actions to enhance the R&D landscape in the country and develop the PtX market.

i. Capacity building: Capacity building in Uruguay faces structural challenges, such as a shortage of experienced professionals in hydrogen technologies, limited access to specialized training equipment, and inadequate coordination between academia and industry. Without investment in technical education and workforce planning, the hydrogen sector may struggle with operational expertise and project execution. Developing human capital is essential for the sustainable growth of the green hydrogen sector. This also involves addressing the workforce needs to support the R&D landscape and the future PtX market development.

ii. Collaborative R&D Programs and Infrastructure: Research activity remains concentrated among a small number of academic groups, with limited private sector involvement. By focusing on the following priorities, Uruguay can build a more robust R&D ecosystem and comprehensive knowledge in PtX that supports the growth of this industry:

   a. Expansion of Research and Development (R&D) Infrastructure: Establish dedicated laboratories for electrolyser testing, synthetic fuel synthesis, and safety assessment to enhance research capabilities.

Analysis of current activities and relevant actors according to the methodology: SWOT Analysis

b. Increase Private Sector Involvement: Encourage greater participation from the private sector in R&D activities to diversify expertise and investment in hydrogen and Power-to-X (PtX) technologies.

c. Creation of Testbeds and Demonstrators: Develop pre-commercial testbeds or demonstration projects for PtX production to validate research findings under conditions relevant to the industry.

iii. **Business development support, project development technical support and financing assistance:** Uruguay should initiate a comprehensive PtX allocation study aimed at fully decarbonizing the industry. This study will develop various scenarios and conduct a thorough sector analysis, outlining necessary actions for the next five years and beyond. It will identify optimal sites for hydrogen and synthetic fuel production while assessing resource availability through the years, logistical considerations, and integration opportunities within existing infrastructure. Additionally, it is crucial to prioritize efforts that assist local businesses in identifying and capitalizing on PtX-related opportunities. This could involve creating new financing mechanisms involving the public and private sector and forming partnerships with international companies to explore potential export markets for hydrogen and its derivatives.

iv. **Regulatory Framework Development:** Uruguay does not yet have dedicated regulations for hydrogen production, transport and storage. There is also no specific regulations or technical standards governing its use in Uruguay. Establishing a robust and clear regulatory environment is crucial for the growth of the green hydrogen sector.

v. **Development of a robust Environmental and Social (E&S) regulatory framework:** Establishing robust E&S regulations ensures that green hydrogen projects are developed sustainably, minimizing environmental impacts and promoting social benefits. This is essential for maintaining public support and fostering long-term viability.

vi. **Assess gaps in Export Infrastructure for PtX products at ports:** To support the hydrogen sector, Uruguay needs to develop essential infrastructure for effective supply chain management. Following research and studies should be addressed:

a. Storage solutions to manage hydrogen supply and demand

b. Study on reintegration of pipelines and distribution networks for hydrogen delivery

c. Necessary upgrades of ports to handle hydrogen exports and imports.

4.8 Relevance of Research and Development Topics

4.8.1 Research on CO_2

To position Uruguay as a leading producer of green hydrogen and PtX, it is essential to consider that the study of CO_2 technologies and all related techno-economic analyses must run parallel to achieve growth in the PtX market. The importance of CO_2 research in Uruguay lies in several favorable conditions the country possesses:

- As previously mentioned, it is attractive for producing green hydrogen due to its energy matrix being almost 100% renewable.
- There are synergies in the local industry, where Uruguay has a significant amount of CO_2 from pulp and paper mills, ethanol production, and some biogas projects—providing Uruguay with the possibility of having biogenic CO_2 resources of about 9 Mt/a.

- Having biogenic CO_2 resources makes it a pioneer and attractive for producing e-fuels, resulting in lower costs—relying solely on DAC may initially be too expensive; diversifying across biogenic and industrial CO_2 sources could help reduce costs while scaling.

Analysis of current activities and relevant actors according to the methodology: SWOT Analysis

Important topics for CO_2 technologies in this R&D Roadmap should include:

Table 5. Research areas in CO_2. Own Compilation, based on (Pingping et al. 2024), (PtX Hub and DECHEMA 2024), (R. Detz et al. 2023), (International PTX Hub 2022)

Topic	R&D activity
CO_2 capture technologies	Focus on low-cost DAC pilots leveraging Uruguay's renewable surplus (when wind/solar overproduce) Explore CO_2 capture from ethanol plants, pulp & paper mills, and biogas as near-term scalable options Hybrid capture systems (e.g., coupling industrial capture with DAC for balancing seasonal variation)
Biogenic and Atmospheric CO_2 Sources	Compare lifecycle impacts of biogenic vs. atmospheric CO_2 streams Seasonal dynamics: pulp and ethanol production vary seasonally; how does that affect hydrogen plant operation?
CO_2 Purification and Conditioning	Study impurities in biogas-derived CO_2 and their effect on PtX catalysts Develop low-energy purification processes (critical for keeping e-fuels competitive)
Technoeconomic analysis	Uruguay-specific cost comparisons of DAC vs. biogenic capture – influences in the LCOF (Levelized Cost of Fuel)
Sustainability Assessments and policies	Influence of the sustainability requirements imposed by RED III (e.g., CO_2 eligibility) and other international regulatory frameworks and certification schemes on the LCOF Public acceptance of DAC and CO_2 pipelines — anticipate social/regulatory aspects early
Infrastructure and Logistics	Feasibility of regional CO_2 transport networks from pulp/ethanol hubs to coastal e-fuel plants Potential for CO_2 shipping hubs (Montevideo, Nueva Palmira) as part of export logistics
Coupling CO_2 Sources with Hydrogen and PtX Systems	Real-time optimization of CO_2 + H_2 flows for e-fuel plants

	Hybrid concepts: pulp mill CO_2 + DAC balancing for steady supply

4.8.2 Research on Synthesis

Power-to-X (PtX) products such as methanol are gaining importance in Uruguay, supported by abundant renewable energy resources and accessible biogenic CO_2 streams. Given the country's strong export orientation, research on methanol synthesis becomes a key priority to ensure competitiveness, sustainability, and alignment with international certification standards.

This chapter outlines the most relevant research areas for advancing methanol synthesis in the context of Uruguay's green hydrogen roadmap, ranging from CO_2 capture and catalytic innovation to process integration, system-level optimization, and emerging technologies. The aim is to highlight where research efforts can generate the greatest impact for Uruguay, both in terms of domestic value creation and global positioning.

Table 6. Research areas in Methanol. Own compilation, based on (Pakdel and Eslamloueyan 2024), (Guil-López et al. 2019), (Siphesihle Mbatha et al. 2024), (Ausfelder et al. 2023), (Siphesihle Mbatha et al. 2021)

Topic	R&D activity
CO_2 Capture and Utilization (CCU) technologies	Direct air capture (DAC) vs. point-source CO_2 (e.g., cement, steel plants)
Catalyst & Process Innovation	Development of low-temperature/low-pressure catalysts (e.g., Cu/ZnO, In_2O_3-based) Catalyst durability and regeneration In-situ catalyst monitoring via spectroscopy
Technoeconomic analysis	Techno-economic analysis of CO_2 purification for methanol synthesis
Integration of Renewable H_2 with Methanol Synthesis	Dynamic operation of PtX plants under real-world renewable variability Hybrid operation: coupling steady-state biomass CO_2 with fluctuating electrolysis
Methanol -downstream routes for export and local industry	SAF (methanol-to-kerosene): for decarbonization of the aviation sector and additionally for exports to international SAF markets MTO/MTA: for local chemical industry Drop-in fuels: for decarbonization of the local shipping sector
	Process integration with local grids: Uruguay's grid is small and renewable-heavy, so PtX flexibility can help balance system stability

	Storage and logistics: infrastructure and strategic for export through ports (Montevideo, Nueva Palmira)
Water management	Development of water management strategies for PtX in Uruguay, including sourcing from non-freshwater streams, purification to synthesis-grade quality, and closed-loop recycling to minimize freshwater use

5 Development of the R&D roadmap

5.1 Objective and purpose of the roadmap

The R&D roadmap for Uruguay is designed to outline the essential phases needed to assess and enhance the country's R&D initiatives, promoting advancements in green hydrogen and PtX projects. It aims to identify and prioritize research areas that consider the unique characteristics and needs of the country. Additionally, it seeks to outline further activities necessary to establish a robust hydrogen and PtX industry in Uruguay. This proposed roadmap is intended to be a crucial component of the national strategy. The initial findings should be viewed as a foundational step in aligning with the national strategy, while recognizing the constraints of resources and time involved in its development. Regular reviews and updates of the national roadmap are essential to incorporate new developments, adapt to changing circumstances, and integrate emerging insights. This continuous refinement will ensure that the roadmap remains relevant and effectively directs the country's efforts in the hydrogen sector, aligning with broader national goals and responding to the evolving energy landscape.

5.2 Implementation plan

5.2.1 Roadmap

Based on the prioritization activities from chapter 4.7, the roadmap is divided into three distinct periods: the foundational and early actions phase from 2026 to 2028, the scaling and demonstration phase from 2029 to 2033, and the integration and global competitiveness stage from 2034 to 2040. Each phase specifies the actions and objectives designed to cultivate a supportive R&D environment for the hydrogen industry in Uruguay, enhance research capabilities, and ultimately position the country as a leader in green hydrogen and PtX technologies.

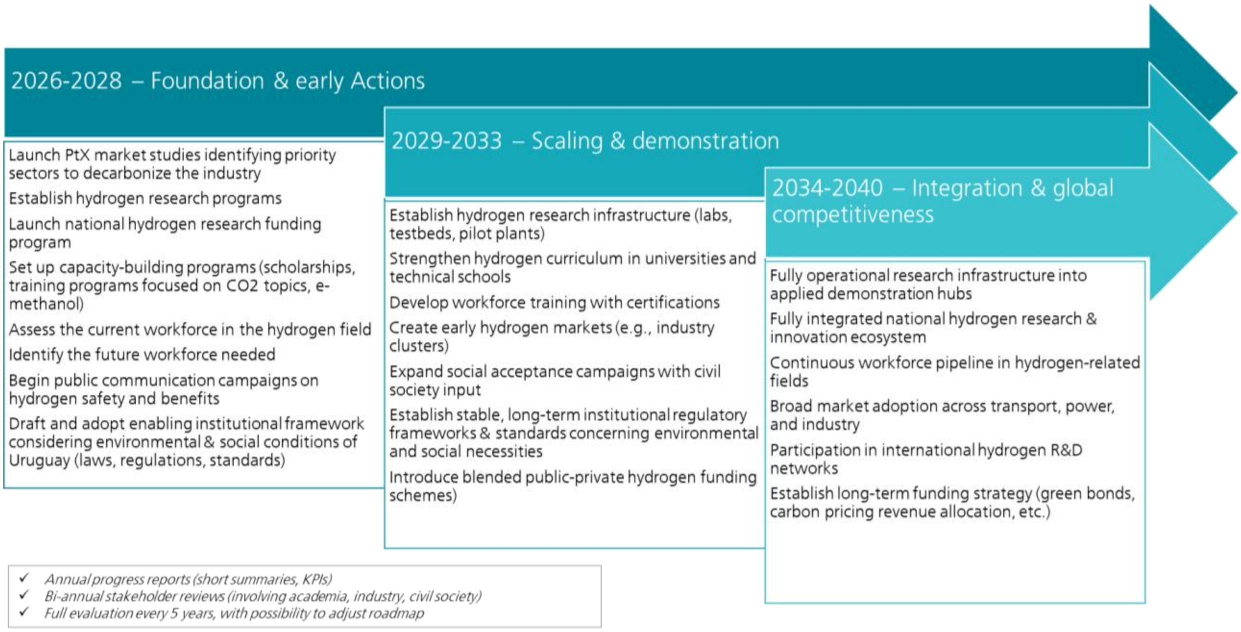


Figure 22. HyUruguay – Development of a R&D Roadmap for green hydrogen in Uruguay. Own illustration

5.2.2 Key stakeholders

This chapter aims to identify potential stakeholders responsible for implementing the activities outlined in the roadmap. The list is not exhaustive; rather, it represents a part of the stakeholder mapping conducted for this project.

In addition to these identified stakeholders, it is important to consider the roles of various groups, such as local communities, educational institutions, and international partners, who may also contribute to the successful execution of the roadmap activities. Engaging a diverse range of stakeholders will ensure a comprehensive approach and foster collaboration across different sectors, ultimately enhancing the effectiveness of the initiative.

2026-2028 – Foundations and early actions

Activity	Stakeholder
Launch PtX market studies	MIEM, MEF, OPP, German Embassy/AHK (link to German industry demand studies, e.g., H2Global)
Establish hydrogen research programs	ANII, CONICYT, MEC, UIH, ONUDI, German Embassy (connections with German R&D institutions, Fraunhofer, universities)
National hydrogen research funding program	MEF, ANII, OPP, German Embassy (bilateral R&D co-financing)
Capacity-building programs (scholarships, CO_2 topics, e-methanol)	MEC, CONICYT, ANII, IICA, German Embassy/AHK (DAAD scholarships, academic exchange)
Assess current/future workforce	MEC, MVOT, MIEM, Uruguay XXI
Public communication campaigns on safety/benefits	MIEM, MEC, MRREE (domestic + international outreach)
Draft enabling institutional framework (laws, standards)	MIEM, URSEA, MEF, MRREE, LATU (standards), German Embassy (knowledge-sharing on German/EU regulations)

2029-2033 – Scaling and Demonstration

Activity	Stakeholder
Hydrogen infrastructure (labs, testbeds, pilots)	Universities e.g., UdelaR/UTEC, ANII, MIEM, ONUDI, AHK, German Embassy/AHK (support tech-transfer)
Strengthening hydrogen curriculum (universities, tech schools)	MEC, CONICYT, ANII, Universities, German Embassy (link with German technical universities, dual training models)
Develop workforce training with certifications	MEC, LATU, ANII
Create early hydrogen markets (industry clusters)	MIEM, MTOP, ANP, Uruguay XXI, MVOT, German Embassy (connect German off-takers and companies)
Expand social acceptance campaigns	MIEM, MEC, civil society, MRREE (embassy can facilitate international dialogue platforms)
Stable institutional frameworks & standards	MIEM, URSEA, MEF, MRREE, LATU (with German/EU alignment support)
Public-private hydrogen funding schemes	MEF, MIEM, OPP, Uruguay XXI, German Embassy (facilitate KfW, EU, and German funding)

2030-2040 – Integration & global competitiveness

Activity	Stakeholder
Operational research infrastructure	Universities e.g., UdelaR / UTEC, ANII, LATU, MIEM, German Embassy/AHK (joint innovation programs)
Integrated hydrogen R&D & innovation ecosystem	Universities e.g., UdelaR / UTEC, ANII, CONICYT, UIH, MEC, German Embassy/AHK (long-term bilateral research collaboration)
Continuous workforce pipeline	MEC, Universities, ANII, German Embassy /AHK (exchange programs, joint PhDs, technical training with German chambers)
Broad market adoption across sectors	MIEM, MTOP, ANP, MVOT, Uruguay XXI, German Embassy / AHK (export partnerships with German industry)
International hydrogen R&D networks	MRREE, MIEM, ANII, ONUDI
Long-term funding strategy (green bonds, carbon pricing revenue allocation)	MEF, OPP, MIEM, Uruguay XXI, German Embassy (access to German & EU green finance)

5.3 Monitoring and evaluation

A Monitoring and Evaluation (M&E) Framework defines how the progress, performance, and impact of a roadmap or program will be measured over time. It serves as a practical guide for assessing whether milestones are being achieved and whether strategic actions are delivering the expected results. For national hydrogen roadmaps, such a framework is essential to ensure that activities remain aligned with overarching objectives, while also providing stakeholders with evidence to adjust strategies when needed. By embedding an M&E Framework into Uruguay's hydrogen roadmap, stakeholders can systematically monitor implementation, strengthen decision-making, and enhance overall effectiveness—ultimately increasing the likelihood of long-term success (Fation Luli 2024).

Core elements of the M&E Framework:

- Annual Progress Reports (Product Masterclass 2024): Led by MIEM, with contributions from OPP and ANII, to provide concise summaries of achievements and challenges.
- Biannual Stakeholder Reviews (Hoferer 2025b), (Product Masterclass 2024): Coordinated by MIEM and OPP, bringing together academia, industry, and civil society; with the German Embassy participating as an observer and partner,
- Five-Year Evaluations (Hoferer 2025b): Independent assessments, facilitated by MRREE to incorporate international benchmarking, with additional comparisons to German/EU standards provided by the Embassy.
- KPI Dashboard (Traffic-Light System) (Trantor 2023): Managed by MIEM, OPP, URSEA, ANP, MTOP, and ANII, offering real-time tracking of key indicators, supplemented by benchmarking against German/EU standards.

5.3.1 Continuous process of the roadmap

Establish a review cycle

To ensure the effectiveness of the R&D roadmap for green hydrogen, regular assessments should be conducted to evaluate its relevance and alignment with established objectives. Scheduling periodic reviews is essential for maintaining adaptability and capturing new opportunities in a rapidly changing environment. Engaging key stakeholders in these assessments will facilitate valuable feedback and ensure that all parties remain aligned with the roadmap's goals. Additionally, continuous PtX allocation studies are crucial for monitoring the landscape, allowing for the identification of potential opportunities and threats. By integrating these practices, the roadmap can evolve in response to emerging trends and challenges, ultimately driving the successful development of the green hydrogen sector (Bastow 2025; Miro 2025).

Continuous improvement

To effectively assess the success of the national strategy roadmap for green hydrogen, it is essential to establish clear Key Performance Indicators (KPIs) and measurement criteria. These metrics will enable tracking progress, identifying areas for improvement, and making data-driven decisions (Trantor 2023). Additionally, incorporating feedback loops from stakeholders is crucial, as their insights significantly influence the roadmap's objectives. Prioritizing these objectives based on direct feedback ensures that the strategy remains relevant and aligned with stakeholder needs (Hoferer 2025a). Furthermore, the roadmap should be flexible and open to adjustments in response to changing dynamics in the hydrogen market and the experiences of project developers. This adaptability allows the roadmap to address unforeseen challenges and seize new opportunities, ensuring its long-term effectiveness and success (Trantor 2023).

5.3.2 Strategies to ensure continuity

This chapter outlines the key strategies to consider when defining actions and activities that facilitate the accelerated and continuous implementation of the roadmap. These measures will promote the overall development of the hydrogen market through the establishment of new R&D programs, policies, standards, and regulations, as well as addressing more intangible factors such as cooperation and public acceptance of green hydrogen (IRENA 2022). Further strategies can be found through Figure 23:

Figure 23. Strategies to ensure continuity of a roadmap as referenced in (IRENA 2024)

5.3.3 Institutionalization of the roadmap

Green hydrogen is still in its initial stage across most applications and requires robust policy support to effectively integrate into the energy transition. This support is crucial for developing the necessary infrastructure, incentivizing research and innovation, and ensuring that the regulatory framework facilitates investment and deployment. By implementing supportive policies, governments can help create a favorable environment for green hydrogen technologies to flourish, contributing to decarbonization efforts and the establishment of a sustainable energy system.

To institutionalize a green hydrogen roadmap in Uruguay, it is essential to create a comprehensive strategy that aligns with national energy goals, establishes well-defined policy frameworks, and promotes collaboration among stakeholders, including government agencies, private sector players, academic institutions, and NGOs. This process involves setting specific targets, implementing supportive measures, and ensuring the presence of high-quality R&D infrastructure. Figure 24 presents a list of actions to consider for the institutionalization of a roadmap (Emanuele Bianco et al. 2022;FONA 2022; Interreg Europe 2024).

Establish a coordinating body	Establish a dedicated entity such as an "Hydrogen Innovation Agency"
	Coordinate with different stakeholders and ensure alignment and efficient resource allocation
Develop a comprehensive policy framework	Integration of existing energy, industrial and environmental policies, which provide cohesion approach to hydrogen development
Secure Sustainable funding mechanisms	Implementation of diverse funding sources, including public R&D grants, private investments and international partnerships e.g., implementation of Carbon Contracts for Differences and tax incentives
Foster Public-Private Partnerships	Collaborations between government entities and private companies to leverage expertise and share risks in the development of the PtX market

Figure 24. Important actions for the institutionalization of a green hydrogen roadmap (Emanuele Bianco et al. 2022; FONA 2022; Interreg Europe 2024)

5.4 Managing acceptance in research institutions

The successful implementation of Uruguay's green hydrogen R&D roadmap requires active engagement and endorsement from the national research and academic community. As a foundational pillar of innovation, research institutions must not only support the strategic direction of the roadmap but also participate actively in its development, validation, and long-term evolution.

In Uruguay, the Universidad de la República (UdelaR) and other academic institutions, such as UTEC, IIBCE, UCU, and UM, have shown initial involvement in hydrogen-related research, focusing on areas such as electrolysis, Power-to-X systems, and CO_2 valorization (UTEC 2025b), (UTEC 2025a), (Ministerio de Industria, Energía y Minería 2024c), (Ministerio de Industria, Energía y Minería 2024d), (Agencia Nacional de Investigación e Innovación 2024). However, for these institutions to align more effectively with the national hydrogen strategy, it is essential to implement targeted initiatives aimed at raising internal awareness, fostering collaboration among the institutions, and promoting a shared commitment to the objectives outlined in the hydrogen roadmap across various faculties and departments. To manage and strengthen acceptance within research institutions, the following actions are recommended:

- Internal Communication and Strategic Alignment: Ministries and lead agencies should engage in regular dialogue with academic stakeholders to explain the roadmap's objectives, expected contributions, and strategic relevance to national development. Roadmap ownership can be fostered through workshops, public lectures, and integration into institutional planning processes (Ministerio de Industria, Energía y Minería 2023a).
- Recognition and Funding Opportunities: Providing dedicated funding schemes, recognition mechanisms, and clear pathways for research career development in hydrogen technologies can increase institutional motivation. This includes specific calls for proposals, postdoctoral grants, and lab infrastructure investment aligned with roadmap priorities (Agencia Nacional de Investigación e Innovación 2024), (Ministerio de Industria, Energía y Minería 2023a), (ANII, 2022; LATU, 2023), (ANII et al. n.d.), (LATU 2022).
- Cross-disciplinary and Inter-institutional Collaboration: Encouraging collaborative research between engineering, environmental sciences, economics, and social sciences—both within and across institutions—can enhance the system-wide understanding and broaden acceptance. Establishing formal hydrogen research consortia or clusters may support this objective (Hydrogen TCP 2024), (IRENA 2024)
- Capacity Building and International Networking: Acceptance is reinforced when researchers are included in global hydrogen knowledge networks. Exchange programs, joint projects with Fraunhofer IEE and European partners, and participation in international hydrogen platforms (e.g., IPHE, Clean Hydrogen Partnership) will help Uruguayan institutions stay at the forefront of knowledge and increase the legitimacy of domestic research initiatives (European Union 2025), (IEA 2024), (IRENA 2023).
- Academic Freedom and Autonomy Considerations: Managing acceptance also requires respecting institutional autonomy and promoting co-design processes. The roadmap should be presented as a shared national challenge—one where researchers are not mere implementers, but active co-creators of Uruguay's hydrogen future.

5.5 Stakeholder engagement and communication

Stakeholder engagement is a critical pillar for the effective development and implementation of Uruguay's green hydrogen R&D roadmap. Given the cross-sectoral nature of hydrogen, successful outcomes depend not only on technical feasibility but also on building trust, transparency, and alignment across public, private, academic, and civil society actors.

Uruguay has laid the groundwork for participatory governance through its inter-institutional H2U Program, which promotes dialogue between ministries, regulatory bodies, research institutions, and strategic investors (Ministerio de Industria, Energía y Minería 2023a). However, broader engagement strategies must ensure that diverse stakeholder groups—such as local communities, environmental organizations, trade unions, and industrial consumers—are consulted and informed throughout the roadmap's lifecycle.

To that end, the following engagement and communication strategies are recommended:

- Structured Multi-Stakeholder Platforms/Organizations: Formal stakeholder dialogue mechanisms should be established at the national and regional levels. These platforms may take the form of advisory councils, technical working groups, or periodic roundtables involving project developers, academia, municipalities, social organizations, and sectoral chambers (Ministerio de Industria, Energía y Minería 2023a).
- Transparent Communication Channels: Public access to information on project progress, environmental assessments, and regulatory developments must be guaranteed through open data portals, public hearings, and multilingual dissemination tools, particularly in regions where projects may impact vulnerable communities (IRENA 2024), (Ministerio de Industria, Energía y Minería 2023a), (IRENA 2023).
- Participatory Planning and Co-Design: The roadmap implementation should integrate participatory tools—such as community consultations, scenario-building workshops, and stakeholder mapping exercises, especially for projects with territorial implications (IMPO 2008). Experiences from other countries demonstrate that co-design processes reduce opposition and accelerate project timelines (IRENA 2024), (IRENA 2023).
- Capacity Building for Civil Society Engagement: To ensure informed participation, tailored training and awareness campaigns should be developed for non-expert stakeholders, particularly in areas such as environmental impacts, water use, hydrogen safety, and employment opportunities (IRENA 2024), (IRENA 2023).
- Strategic Messaging and Public Perception: Public communication should highlight the potential of green hydrogen as a driver of inclusive and sustainable development, emphasizing national benefits (economic diversification, job creation, export capacity) as well as environmental safeguards (climate action, biodiversity protection). Messaging must be adapted to different audiences (urban vs. rural, technical vs. general public) and media platforms (European Union 2025), (IRENA 2024), (IEA 2024).

Uruguay's strong institutional credibility and existing experience with participatory energy planning (e.g., in wind and biomass projects) provide a solid foundation for a transparent and inclusive hydrogen strategy. Sustained engagement and communication efforts will be essential to build long-term legitimacy, avoid social conflicts, and ensure that the energy transition is equitable and democratically owned.

5.6 Best practices and case studies

5.6.1 Successful examples from other countries or sectors

EU Hydrogen Strategy:

The EU strategy aims to provide a comprehensive perspective on the hydrogen value chain by establishing a supportive governance system and policy framework that facilitates the deployment of hydrogen. EU policymakers aspire to position European industry as a global leader in both green hydrogen technology and zero-carbon heavy industry. Consequently, the strategy highlights green hydrogen as the only form of hydrogen compatible with a net-zero emissions system. Important key aspects and instruments referenced in the EU hydrogen strategy are illustrated in Figure 25 (IRENA 2021).

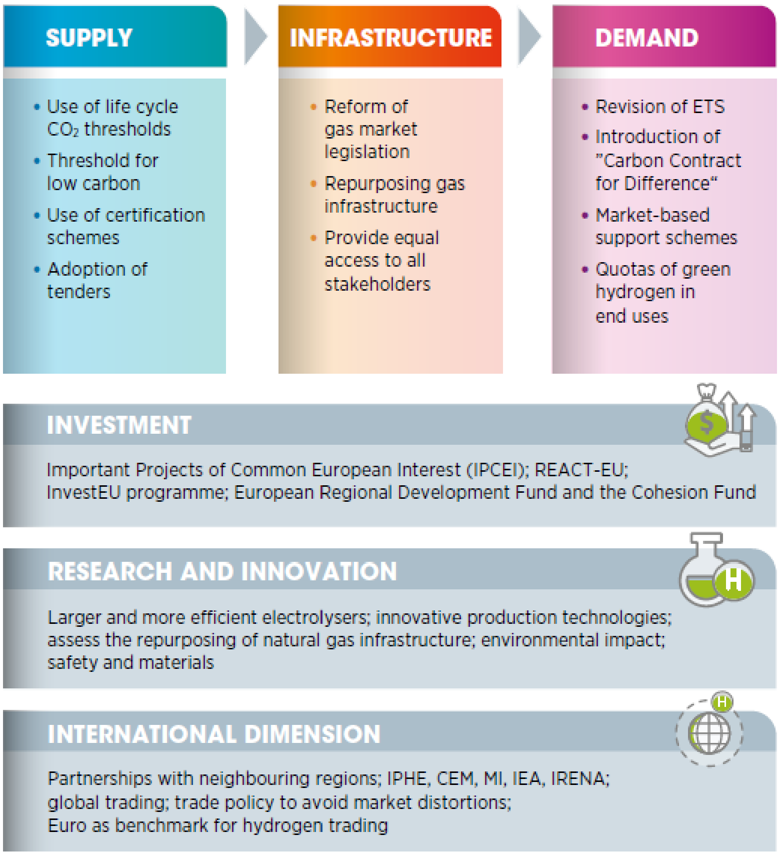


Figure 25. Key aspects and instruments presented in the EU hydrogen strategy (IRENA 2021)

Green Hydrogen Action Plan 2023-2030 in Chile:

The Chilean Government's Green Hydrogen Action Plan 2023-2030 outlines a comprehensive strategy to position Chile as a global leader in green hydrogen production and export. The plan encompasses specific measures across strategic areas, aiming to develop sustainable green hydrogen and PtX market. Some of the key actions and strategies that shaped the plan are in Figure 26 (IRENA 2024), (Gobierno de Chile 2024):

Strategic planning

- Action Plan Development (2022-2023) was developed through participatory process with industries representatives and civil society organizations

Stakeholder engagement

- Measures such as citizen participaton were considered for the development of the action plan. The government launched a dedicated website to facilitate public involvement
- An Strategic Advisory Council and a Strategic Advisory Committee were established to provide expert guidance

Regulatory adjustments

- Government proposed the Framework Law on Sectoral Authorizations aiming to reduce permit approval times by 30% and establish a unified permit information system
- The Chilean Environmental Impact Assessment Service introduced uniform criteria for assessing the environmental impact of green hydrogen projects
- There are also plans to develop a sustainability certification system aligned with international standards

Financial Instruments an Incentives

- H2V Facility: government established a financial facility with USD 1 Billion through CORFO to support private investment
- Tax incentives: government proposed tax reforms which include reducing the income tax rate for companies developing decarbonization technologies and enhancing tax credits for R&D activities

Infrastructure Development and Regional Focus

- Strategies such as allocation of state-owned lands and enhance of infrastructure of ports and energy transmission systems are considered
- Integration of electrolyser equipment into technical-professional high schools was considered

Figure 26. Key aspects and actions presented in the Green Hydrogen Action Plan in Chile (Gobierno de Chile 2024)

6 Conclusion and recommendations

6.1 Summary of key findings based on the analysis

The analysis indicates that Uruguay possesses a unique combination of abundant natural resources and institutional stability; however, it faces significant challenges in areas such as infrastructure, workforce development, and social acceptance. This duality plays a critical role in shaping the country's potential to become a prominent hub for green hydrogen and Power-to-X (PtX) technologies in Latin America.

Although Uruguay has set ambitious targets for market development, its actual progress has been slower than required to meet these objectives. This gap raises important questions regarding the specific barriers that impede the growth of the hydrogen and PtX industry. Regulatory, research and development, and economic challenges must be identified and addressed to facilitate progress.

A robust R&D landscape is essential for the growth of the hydrogen and PtX sectors, as it fosters innovation, drives technological advancements, and enhances the overall competitiveness of the industry. Given the slow pace of market development, this roadmap identifies key areas for advancing the green hydrogen and PtX industry in Uruguay, including:

- Research and Development: Strengthening R&D efforts to explore new technologies and hydrogen-related topics will enhance the efficiency and profitability of PtX projects.
- Capacity Building: Investing in education and training is crucial for equipping the workforce with the skills needed to excel in the evolving industry.
- Support for PtX Market Development: Conducting PtX market studies to develop decarbonization scenarios, including a detailed analysis of resources and infrastructure, is essential.
- Business Development: Encouraging entrepreneurship and supporting the establishment of new ventures in the hydrogen and PtX sectors will be vital for stimulating economic activity and fostering innovation.
- Technical Assistance: Offering guidance and resources to businesses, including best practices for technology implementation and project management, will enhance operational capabilities and ensure successful project execution.
- Regulatory frameworks and financing mechanisms: Establishing supportive regulatory frameworks and financial mechanisms will facilitate market entry, attract investment, and promote sustainable growth.

Strengthening international partnerships could also play a vital role in facilitating knowledge and resource sharing, thereby accelerating market development. Additionally, a long-term perspective is crucial for attracting investment and enabling sustainable growth, which necessitates the establishment of clear and stable regulatory frameworks. Engaging local communities and addressing environmental considerations in planning processes are critical, as factors such as water usage, land availability, and social license significantly influence project viability.

6.2 Recommendations

This roadmap also offers practical recommendations and actions tailored to strengthen research and development in Uruguay’s green hydrogen and PtX sectors, addressing the country's unique context and needs.

Recommendation 1: Research infrastructure and programs

Dedicated Research Center: Assess the feasibility of a specialized PtX research center in strategic locations such as Montevideo or coastal regions considering the following aspects:

Aspect	Considerations
Strategic Location	- Proximity to maritime industries and ports.
	- Access to renewable energy sources (e.g., wind, solar).
Collaboration Opportunities	- Engage with local universities and research institutions.
	- Foster partnerships with maritime companies for joint projects.
Funding and Resources	- Explore government grants and international funding opportunities.
	- Assess potential private sector investment.
Infrastructure Needs	- Evaluate existing facilities and infrastructure for research.
	- Consider the availability of laboratories and testing sites.

Targeted Support on R&D topics:
To effectively support the R&D programs, it is essential to identify key priority areas for government and institutional focus. This should include backing research initiatives aimed at CO_2 utilization and the production of synthetic fuels. By providing funding, resources, and incentives in these areas, Uruguay can stimulate innovation and enhance its position within the PtX research sector.

Recommendation 2: Capacity building

Tailored Training Programs
To address the growing demand in the PtX sector (Power-to-X), tailored training programs should be developed. These programs need to provide the specific skills required in this industry. It is essential to involve local universities and technical schools to ensure that the training is practical and relevant. By closely collaborating with educational institutions, we can ensure that future professionals are well-prepared for market demands.

Global Collaboration
In addition, partnering with international research networks is crucial. Exchanging knowledge and technologies in offshore hydrogen production and synthetic fuels, can bring advanced methods and innovations to Uruguay. This global collaboration will not only advance research but also enhance the competitiveness of the Uruguayan industry in the international arena.

Community Awareness

To foster acceptance and understanding of hydrogen technologies within the community, awareness campaigns should be launched. These campaigns can highlight the safety, benefits, and economic opportunities associated with hydrogen technologies. By raising awareness among local communities, we create an understanding of the possibilities offered by the PtX sector and encourage more individuals to engage in this forward-looking development.

Recommendation 3: Workforce and education

Workforce Assessment

To effectively meet Uruguay's hydrogen goals, it is essential to conduct a thorough evaluation of the current workforce. This assessment should identify the number of trained professionals required across various sectors involved in hydrogen production and utilization. By understanding the existing skill gaps, we can better plan for targeted recruitment and training initiatives that align with national hydrogen strategies.

Integrated Educational Strategy

An integrated educational strategy is key to developing a skilled workforce for the PtX sector. This approach should combine vocational training, university programs, and industry partnerships to create a comprehensive educational framework. By aligning educational offerings with industry needs, we can ensure that students receive a well-rounded education that equips them with the necessary skills and knowledge to thrive in the hydrogen economy.

Continuous Evaluation

To stay ahead in a rapidly evolving industry, it is crucial to regularly review and update training programs. Continuous evaluation will help ensure that these programs remain relevant and effectively address the changing technological developments and industry requirements. By fostering a culture of adaptability and responsiveness in education, we can better prepare the workforce for future challenges and opportunities in the hydrogen sector.

Recommendation 4: Market development & decarbonization of the industry

PtX allocation study:

To effectively facilitate the growth of the PtX market and large-scale business development in Uruguay, it is essential to conduct a detailed PtX allocation study. The allocation study would focus on identifying optimal resource distribution, priority industry sectors, investment priorities, and infrastructure needs across the key phases of development, including:

- Market Research & Feasibility Studies - Assessing potential sites, resources for hydrogen production and targeted industry to sectors which are prioritized to decarbonize.
- Pilot Projects for Hydrogen Production - Determining the most effective pilot projects to implement based on the allocation of resources.
- Infrastructure Development - Identifying infrastructure requirements and potential locations for development.
- Commercial Scale Production & Distribution - Allocating resources for scaling production and establishing distribution networks.
- Full Market Integration & Export Opportunities - Evaluating the necessary steps for integrating into the broader market and exploring export possibilities.

Local Market Insights

Collaboration with universities and research centers is vital to gain insights into Uruguay's economic landscape and the potential for PtX technologies. By conducting studies that examine local resources, market conditions, and the needs of various industries, stakeholders can develop strategies that are tailored to the unique characteristics of Uruguay. This data-driven approach will ensure that the growth path for the PtX market aligns with national goals and maximizes economic opportunities.

Recommendation 5: Social acceptance and communication

It is recommended to develop a national communication and citizen engagement plan around green hydrogen. This plan should include public consultations, awareness campaigns, and transparent mechanisms on environmental and social impacts. Community acceptance will be a critical factor in enabling large-scale projects.

Recommendation 6: Stable institutional framework

It is essential that the roadmap is supported by a stable institutional framework capable of transcending government cycles. The creation of a permanent inter-institutional body or a national hydrogen law would provide predictability and legal certainty for investors.

Recommendation 7: Funding strategy

It is recommended to design a financing strategy that combines national and international instruments, including sovereign green bonds, multilateral funds, and blended finance mechanisms. These tools can accelerate the mobilization of private capital and reduce the risks associated with early investments in green hydrogen.

7 Annex

7.1 Results from the interviews

Activity Description	Score
In-person/on-site capacity building & training services	95
Support for identifying PtX-related business opportunities	93
Online capacity building services	87
Lack of holistic know-how in the field of PtX	86
Information services such as PtX market analysis	86
Support in PtX project development (site identification, techno-economic analysis, etc.)	84
Export infrastructure for PtX products at ports is missing	83
Lack of long-term perspective due to changing international regulatory conditions	83
Lack of pilot-scale and lab-scale training facilities	82
Matchmaking services for domestic industries and international R&D partnerships	82
Lack of clarity regarding certification and Guarantees of Origin	77
CO_2 purification from industrial off-gases and CO_2 capture from air is expensive	73-72
Shortage of skilled workforce in general	74
Unclear international export regulations for hydrogen, ammonia, and methanol	70
Transportation of gases and liquefied products (H2, CO2, N2, NH3, methanol) is difficult/expensive	68
Renewable Energy feed-in tariffs and taxes on electricity use decrease the economic competitiveness of green hydrogen production	68
Integration of individual technologies into a PtX synthesis value chain is difficult	63
National laws and regulations constitute a barrier	55
Political support for PtX development is insufficient	53
High costs of large-scale seawater purification	48
Pipeline transport of purified seawater is difficult/expensive	46
Competition for water resources (drinking water, agriculture, industrial use)	46
Distance of renewable energy generation sites from large industrial hubs	46
Competition of generation with residential and other industrial energy demand	38
Water scarcity in regions with the highest solar power potential	38

Recommendations on development of regulations frameworks in Uruguay:

- Establishment of Dedicated Regulations for Hydrogen Production: Developing specific regulations tailored to hydrogen production, particularly for new green hydrogen projects, to create a clear permitting framework beyond general industrial and energy regulations.
- Creation of Technical Standards: Developing specific regulations and technical standards for hydrogen, including quality standards and guidelines for blending hydrogen into natural gas pipelines. This will be essential for upcoming pilot projects.
- Development of Detailed Regulations: There is a need to establish comprehensive regulations for the construction and operation of hydrogen transport infrastructure, specifically for pipelines, including guidelines on materials, pressure, and safety distances.
- Regulations for Maritime Exports: Uruguay should focus on creating specific domestic regulations for handling the export of hydrogen, ammonia, and methanol, as current regulations are still in the early stages of development.
- Integration of Existing Regulations: While hydrogen transport by road is currently governed by existing regulations for dangerous goods, it's important to ensure that these regulations are effectively integrated and updated to accommodate hydrogen transport.
- Implementation of Effective Frameworks: While existing frameworks for other gases, such as compressed natural gas (CNG), can serve as analogies, it is crucial to implement these frameworks effectively for hydrogen.
- Integration of International Standards: Applying international standards for hydrogen production and usage on a broader scale to ensure best practices are followed while developing local regulations.
- Development of a Guarantee-of-Origin Certification: Creating a certification system for green hydrogen, potentially expanding Uruguay's renewable electricity certificate system (SCER) to include renewable hydrogen.
- Development of a Robust Environmental and Social (E&S) Regulatory Framework: Establishing robust E&S regulations ensures that green hydrogen projects are developed sustainably, minimizing environmental impacts and promoting social benefits. This is essential for maintaining public support and fostering long-term viability.

8
Publication bibliography

Administración de Ferrocarriles de Estado: AFE AVANZA EN PROYECTO DE TREN DE PASAJEROS BINACIONAL ENTRE SALTO GRANDE Y CONCORDIA. Available online at https://www.afe.com.uy/afe-avanza-en-proyecto-de-tren-de-pasajeros-binacional-entre-salto-grande-y-concordia/, checked on 10/26/2025.

Administración Nacional de Puertos (2024a): Memoria Anual 2023. Montevideo, Uruguay. Available online at https://anp.com.uy/sites/default/files/archivos/parrafo-colapsable/2024-05/MEMORIA%20ANUAL%202023_web_c.pdf, checked on 10/26/2025.

Administración Nacional de Puertos (2024b): Port of Nueva Palmira. ANP. Available online at https://anp.com.uy/en/home/ports/commercial/port-nueva-palmira.

Administración Nacional de Puertos (2025): Port of Salto. Available online at https://anp.com.uy/en/home/ports/commercial/port-salto, checked on 10/26/2025.

Agencia Nacional de Investigación e Innovación (2024): PROYECTOS DE INVESTIGACIÓN EN HIDRÓGENO VERDE. Available online at https://www.anii.org.uy/apoyos/investigacion/390/proyectos-de-investigacion-en-hidrogeno-verde/, checked on 10/27/2025.

AHK Uruguay (2024): Desarrollo Sostenible en Proyectos de Hidrógeno y sus Derivados. Available online at https://www.ahkacademy.uy/slides/desarrollo-sostenible-en-proyectos-de-hidrogeno-y-sus-derivados-20, checked on 10/24/2025.

Ámbito (2023): El Puerto de Montevideo movilizó más de 1 M de contenedores en 2022. Available online at https://www.ambito.com/uruguay/el-puerto-montevideo-movilizo-mas-1-m-contenedores-2022-n5693008.

ANCAP (2023): MEMORIA 2023. Available online at https://www.ancap.com.uy/innovaportal/file/19370/1/11-memoria-2023.pdf, checked on 6/2/2025.

Andrea Janics (2008): Auslegung und Inbetriebnahme einer Versuchsanlage zur Methanisierung von Synthesegas aus der Kohlevergasung. Diplomarbeit. Technische Universität Graz, Graz. Wärmetechnik. Available online at https://diglib.tugraz.at/download.php?id=576a8da792a93&location=browse, checked on 11/16/2022.

ANII (2023): Uruguay da importante paso hacia el desarrollo del hidrógeno verde con la concreción del primer proyecto piloto. Available online at https://www.anii.org.uy/noticias/288/uruguay-da-importante-paso-hacia-el-desarrollo-del-hidrogeno-verde-con-la-concrecion-del-primer-proyecto-piloto/, checked on 10/24/2025.

ANII; LATU; MIEM; H2 Uruguay (n.d.): FONDO SECTORIAL DE HIDRÓGENO VERDE. CONVOCATORIA A PROYECTOS DE HIDRÓGENO VERDE. Available online at https://www.anii.org.uy/upcms/files/llamados/documentos/bases-fondo-sectorial-hidrogeno-verde-vf-08042022.pdf, checked on 10/27/2025.

Ausfelder, Florian; Blaumeiser, Dominik; Boumrifak, Chokri; Frank, Daniel; Kotzur, Maximiliam; Lucht Uribe, Andrés; Track, Thomas (2023): Water-for-X. Water for sustainable hydrogen production and follow-up PtX processes. Available online at https://dechema.de/dechema_media/Downloads/Positionspapiere/2023+Water_for_X+Roadmap-p-20010034.pdf.

Balance Energético Nacional Uruguay (2024): Balance Energético 2023. Available online at https://ben.miem.gub.uy/descargas/1balance/1-1-Libro-BEN2023.pdf, checked on 5/26/2025.

Bastow, Janna (2025): Product Roadmap Best Practices - 11 Do's & Don't to Instantly Improve Your Roadmap. In *ProdPad*, 2025. Available online at https://www.prodpad.com/blog/product-roadmap-best-practice-things-to-avoid/, checked on 6/3/2025.

BID Invest (2022): Uruguay – Ferrocarril Central PPP Project Summary. Available online at https://www.idbinvest.org/sites/default/files/2019-04/ESRS%20CENTRAL%20RAIL-ROAD.pdf, checked on 10/26/2025.

bnamericas (2016): Uruguay seeks LNG terminal partner. Available online at https://www.bnamericas.com/en/news/uruguay-seeks-lng-terminal-partner#:~:text=%22Due%20to%20its%20location%20and,com.uy%20for%20more%20information.&text=Gas%20Sayago%20extended%20the%20deadline,Legal%2C%20Financial%20and%20Insurance%20industries., checked on 10/26/2025.

Brener, Tatiana Scherz (2024): Estudio minimiza el impacto del uso de agua en la producción de hidrógeno verde en Uruguay. In *EL PAIS*, 4/24/2024. Available online at https://www.elpais.com.uy/sostenible/estudio-minimiza-el-impacto-del-uso-de-agua-en-la-produccion-de-hidrogeno-verde-en-uruguay, checked on 5/26/2025.

Bundesministerium für Wirtschaft und Klimaschutz (2024): Importstrategie für Wasserstoff und Wasserstoffderivate. Berlin. Available online at https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/importstrategie-wasserstoff.pdf?__blob=publicationFile&v=18, checked on 12/2/2024.

CAF (2023a): CAF helps expand green hydrogen market in Uruguay. CAF signed a Non-reimbursable Technical Cooperation Agreement with UTE to expand the green hydrogen market in Uruguay. CAF Development Bank of Latin America and the Caribbean. Available online at https://www.caf.com/en/currently/news/caf-helps-expand-green-hydrogen-market-in-uruguay/, checked on 10/26/2025.

CAF (2023b): CAF helps expand green hydrogen market in Uruguay. In *CAF*, 10/23/2023. Available online at https://www.caf.com/en/currently/news/caf-helps-expand-green-hydrogen-market-in-uruguay/, checked on 5/27/2025.

CERES (2021): La Cuenca de la Laguna Merín como Polo de Desarrollo. Available online at https://ceres.uy/admin/uploads/slides/archivo_1668794921.pdf, checked on 10/26/2025.

CLM (2023): La Paloma Hub – First Latin American port designed for the storage and export of green hydrogen, ammonia, and synthetic fuels. Edited by C. Uruguay.L.M. Corporate website. Available online at https://clmulti.com/en/la-paloma-hub/, checked on 10/26/2025.

Diario Cambio (2022): Proyecto de producción de Metanol se extendería por distintos departamentos del país. In *Diario Cambio Salto*, 11/13/2022. Available online at https://diariocambio.com.uy/2022/11/13/proyecto-de-produccion-de-metanol-se-extenderia-por-distintos-departamentos-del-pais/, checked on 5/27/2025.

Díaz, Pamela (2024): El 80% de posibles afectados por planta de hidrógeno verde en Tacuarembó no conoce o sabe poco del proyecto. La Universidad de la República concluyó que la población que vive en la zona de influencia de la iniciativa "no tiene información sobre sus implicaciones y no ha tenido instancias de participación 'efectiva y real'". Available online at https://www.elpais.com.uy/informacion/sociedad/el-80-de-posibles-afectados-por-planta-de-hidrogeno-verde-en-tacuarembo-o-conoce-poco-el-proyecto, checked on 10/26/2025.

Djunisic, Sladjana (2023): Uruguay, Port of Rotterdam ink green hydrogen MoU. Renewables Now. Available online at https://renewablesnow.com/news/uruguay-port-of-rotterdam-ink-green-hydrogen-mou-822885/, checked on 10/24/2025.

EEAS (2025): EU Projects with Uruguay. Available online at https://www.eeas.europa.eu/uruguay/eu-projects-uruguay_en, updated on 5/27/2025, checked on 5/27/2025.

El Pais (2023): El potencial de Uruguay para producir fertilizantes verdes. In *EL PAIS*, 7/3/2023. Available online at https://www.elpais.com.uy/economia-y-mercado/el-potencial-de-uruguay-para-producir-fertilizantes-verdes, checked on 5/27/2025.

Emanuele Bianco; Manuel Albaladejo; Smeeta Fokeer; Nele Wenck; Petra Schwager (2022): Industrial and innovation policy can speed up the Green Hydrogen transition | Industrial Analytics Platform. Available online at https://iap.unido.org/articles/industrial-and-innovation-policy-can-speed-green-hydrogen-transition, updated on 6/3/2025, checked on 6/3/2025.

Enel foundation (2019): Inception Report. Variable Renewable Energy Sources (VRES) deployment and role of interconnection lines for their optimal exploitation: the Argentina-Brazil-Uruguay case study. Available online at https://www.enelfoundation.org/content/dam/enel-foundation/topics/2019/05/vres-and-grid-interconnection-in-south-america--argentina%2C-brazil-and-uruguay/Inception_report_Cluster_2.pdf, checked on 5/26/2025.

ENERTRAG (2025): Tambor: E-methanol from green hydrogen. Available online at https://enertrag.com/projects-show-cases/hydrogen-projects/tambor-e-methanol-from-green-hydrogen, updated on 6/2/2025, checked on 6/2/2025.

Estratégica, Energía (2023): Uruguay avanza en el primer Proyecto de Hidrógeno Verde desarrollado por las empresas CIR y SACEEM. In *Energía Estratégica*, 6/8/2023. Available online at https://www.energiaestrategica.com/uruguay-avanza-en-el-primer-proyecto-de-hidrogeno-verde-desarrollado-por-las-empresas-cir-y-saceem/#, checked on 6/3/2025.

European Union (2025): EUROCLIMA: Building a Green and Just Transition with Latin America and the Caribbean. Available online at https://capacity4dev.europa.eu/projects/euroclima_en, checked on 10/27/2025.

Fation Luli (2024): Demystifying the M&E Framework: A Guide for Effective Evaluation. Available online at https://www.evalcommunity.com/career-center/me-framework/, updated on 3/16/2025, checked on 6/3/2025.

Federal Ministry for Economic Affairs and Climate Action (2024): Climate and energy partnerships and energy dialogues. Available online at https://www.giz.de/de/downloads/bmwk2024-en-climate-and-energy-partnerships-and-energy-dialogues.pdf, checked on 10/24/2025.

Federal Ministry for Economic Affairs and Energy (2023): German-Uruguayan Energy Partnership. Available online at https://climateandenergypartnerships.org/partner/german-uruguayan-energy-partnership, checked on 10/26/2025.

FONA, Research for sustainability (2022): Action 2: Establishing green hydrogen in Germany. Available online at https://www.fona.de/en/fona-strategy/actions/action-2.php, updated on 6/3/2025, checked on 6/3/2025.

Freight Amigo: Understanding TEU: The Standard Unit for Measuring Shipping Container Capacity. Available online at https://www.freightamigo.com/blog/understanding-teu-the-standard-unit-for-measuring-shipping-container-capacity.

Gallardo, Felipe Ignacio; Monforti Ferrario, Andrea; Lamagna, Mario; Bocci, Enrico; Astiaso Garcia, Davide; Baeza-Jeria, Tomas E. (2017): A Techno-Economic Analysis of solar hydrogen production by electrolysis in the north of Chile and the case of exportation from Atacama Desert to Japan (26). Available online at https://www.fing.edu.uy/sites/default/files/2023-08/Hidr%C3%B3geno%20Verde%20Producci%C3%B3n%20y%20Usos%20%282023%29.pdf, checked on 6/3/2025.

GH2: Uruguay - GH2 Country Portal – Uruguay. Green Hydrogen Organisation. Available online at https://gh2.org/countries/uruguay, checked on 10/26/2025.

GHIC (2025): GH Import. Available online at https://isa-ghic.org/gh-import, updated on 5/27/2025, checked on 5/27/2025.

GIZ (2024): Climate and Energy Partnership Uruguay-Alemania. Available online at https://www.giz.de/en/worldwide/201028.html, updated on 10/2024, checked on 5/27/2025.

Global Construction Review (2021): Belgian company to spend $455m to create "South America's most modern port". Available online at https://www.globalconstructionreview.com/belgian-company-spend-455m-create-south-americas-m/, checked on 10/31/2025.

Global Energy Monitor Wiki (2025a): Southern Cross Gas Pipeline. Available online at https://www.gem.wiki/Southern_Cross_Gas_Pipeline, checked on 10/26/2025.

Global Energy Monitor Wiki (2025b): GNL Del Plata FSRU. Available online at https://www.gem.wiki/GNL_Del_Plata_FSRU, checked on 10/26/2025.

Gobierno de Chile (2024): Green Hydrogen Action Plan 2023-2030. Available online at https://energia.gob.cl/sites/default/files/documentos/green-hydrogen_action-plan.pdf, checked on 10/24/2025.

Government of the Netherlands (2025): Joint statement of Uruguay and The Netherlands on collaboration in the field of green hydrogen import and export. Available online at https://www.government.nl/documents/diplomatic-statements/2021/11/10/joint-statement-of-uruguay-and-the-netherlands-on-collaboration-in-the-field-of-green-hydrogen-import-and-export, updated on 5/27/2025, checked on 5/27/2025.

Guil-López, R.; Mota, N.; Llorente, J.; Millán, E.; Pawelec, B.; Fierro, J. L.G.; Navarro, R. M. (2019): Methanol Synthesis from CO2: A Review of the Latest Developments in Heterogeneous Catalysis. Available online at https://pmc.ncbi.nlm.nih.gov/articles/PMC6926878/.

Hoferer, Sophia (2025a): Product Roadmap Creation: The 4 Essential Steps, 3/31/2025. Available online at https://www.itonics-innovation.com/blog/steps-to-create-your-product-roadmap, checked on 6/3/2025.

Hoferer, Sophia (2025b): Product Roadmap Creation: The 4 Essential Steps. Available online at https://www.itonics-innovation.com/blog/steps-to-create-your-product-roadmap#typical-structure-and-key-elements-of-a-product-roadmap, checked on 10/25/2025.

Hydrogen TCP (2024): GLOBAL COLLABORATION FOR RESEARCH AND INNOVATION IN HYDROGEN TECHNOLOGIES. Latin America. Available online at https://www.ieahydrogen.org/wp-content/uploads/2024/10/Workshop_H2_collaboration_2024_IEA-Hydrogen-TCP.pdf, checked on 10/27/2025.

HydrogenCentral (2025): China Expected to be World's Largest Importer of Clean Hydrogen, Deloitte Says as it Urges World to Scale up Production Capacity by 2050_FuelCellChina, the Leading Information Hub of Hydrogen and Fuel Cell Industry around the Globe. Available online at https://www.fuelcellchina.com/Industry_information_details/932.html, updated on 5/27/2025, checked on 5/27/2025.

IEA (2024): Global Hydrogen Review 2024. IEA. Available online at https://www.iea.org/reports/global-hydrogen-review-2024, checked on 10/24/2025.

IMPO (1978): Código de Aguas N° 14859. Available online at https://www.impo.com.uy/bases/codigo-aguas/14859-1978, checked on 10/26/2025.

IMPO (2000): Ley N° 17283 - LEY DE PROTECCION DEL MEDIO AMBIENTE. Available online at https://www.impo.com.uy/bases/leyes/17283-2000, checked on 10/26/2025.

IMPO (2005): Decreto N.° 349/005: Reglamento de Evaluación de Impacto Ambiental y Autorizaciones Ambientales. Available online at https://www.impo.com.uy/bases/decretos-originales/349-2005, checked on 10/26/2025.

IMPO (2008): Ley N° 18308 - LEY DE ORDENAMIENTO TERRITORIAL Y DESARROLLO SOSTENIBLE. Available online at https://www.impo.com.uy/bases/leyes/18308-2008, checked on 10/26/2025.

IMPO (2009): Ley N° 18610. LEY DE POLITICA NACIONAL DE AGUAS. PRINCIPIOS RECTORES. Available online at https://www.impo.com.uy/bases/leyes/18610-2009, checked on 10/26/2025.

IMPO (2011): Ley N° 18786 - LEY DE PARTICIPACION PUBLICO PRIVADA. Available online at https://www.impo.com.uy/bases/leyes/18786-2011, checked on 10/26/2025.

IMPO (2020): Ley N° 19889 - APROBACION DE LA LEY DE URGENTE CONSIDERACION. LUC. LEY DE URGENCIA. Available online at https://www.impo.com.uy/bases/leyes/19889-2020, checked on 10/26/2025.

IMPO (2022): En Uruguay existe una ley que garantiza la protección del medio ambiente. Ley N° 17.283 del 28 de noviembre de 2000 – Ley General de Medio Ambiente. Available online at https://www.impo.com.uy/medioambiente/, checked on 10/26/2025.

IMPO (2024): Decreto N° 351/024 - REGLAMENTACION DEL ART. 5 DE LA LEY 17.033, AUTORIZANDO A ANCAP EL USO DE LAS AREAS OFFSHORE, EN LA ZONA CONTIGUA Y ZONA ECONOMICA EXCLUSIVA DE LA REPUBLICA ORIENTAL DEL URUGUAY, EN LA DEFINICION DE AREAS FACTIBLES DE PRODUCCION DE HIDROGENO VERDE Y/O DERIVADOS. Available online at https://www.impo.com.uy/bases/decretos/351-2024, checked on 10/26/2025.

INALOG; Uruguay XXI (2016): Informe del Sector Logístico en Uruguay: Oportunidades de Inversión. Montevideo, Uruguay. (pp. 15–17, 21–22.).

INEFOP: El sector portuario en Uruguay. Available online at https://www.inefop.org.uy/docs/Sector_portuario.pdf, checked on 10/31/2025.

InfoNegocios (2023): Aleteando el sueño del hub portuario: inversión de US$ 1.600 millones para convertir a La Paloma en un polo logístico internacional. Available online at https://infonegocios.biz/nota-principal/aleteando-el-sueno-del-hub-portuario-inversion-de-us-1-600-millones-para-convertir-a-la-paloma, checked on 10/26/2025.

Instituto Nacional de Logística (2016): INFRAESTRUCTURA PORTUARIA. INALOG. Available online at https://www.inalog.org.uy/es/infraestructura-puertos-libres/#:~:text=Est%C3%A1%20ubicado%20en%20la%20ciudad,Terminales%20Graneleras%20Uruguayas%20(TGU).&text=El%20Puerto%20de%20Nueva%20Palmira%20cuenta%20con%20dos%20importantes%20ventajas,Libre%20o%20de%20Zona%20Franca.&text=Argentina%2C%20Bolivia%2C%20Brasil%2C%20Paraguay,%2C%20cereales%2C%20fertilizantes%20y%20combustibles.

Inter-American Development Bank (2019): Technical Cooperation UR-T1328: Supporting Uruguay’s Green Hydrogen Ecosystem. IDB. Available online at https://www.iadb.org/en/project/UR-T1223, checked on 10/26/2025.

International Development Bank (2023): Towards Uruguay's second sustainable energy transition through efficient electrification and green hydrogen. Available online at https://www.iadb.org/en/project/UR-T1286, checked on 10/24/2025.

International Energy Agency (2021): Global Hydrogen Review 2021. Available online at https://www.iea.org/reports/global-hydrogen-review-2021.

International PTX Hub (2022): PtX Sustainability Dimensions and Concerns. Berlin. Available online at https://ptx-hub.org/wp-content/uploads/2022/05/PtX-Hub-PtX.Sustainability-Dimensions-and-Concerns-Scoping-Paper.pdf, checked on 5/23/2023.

International Trade Administration (2021): Uruguay Offshore Green Hydrogen Project. susan.lusi@trade.gov. Available online at https://www.trade.gov/market-intelligence/uruguay-offshore-green-hydrogen-project, updated on 6/2/2025, checked on 6/3/2025.

Interreg Europe (2024): Public-private collaboration to develop a broad green hydrogen ecosystem and roadmap in Mallorca. Available online at https://www.interregeurope.eu/good-practices/public-private-collaboration-to-develop-a-broad-green-hydrogen-ecosystem-and-roadmap-in-mallorca-0, updated on 6/3/2025, checked on 6/3/2025.

IRENA (2021): MAKING THE BREAKTHROUGH. Green hydrogen policies and technology costs. Available online at ISBN 978-92-9260-314-4, checked on 10/24/2025.

IRENA (2022): Enabling Measures Roadmap for Green Hydrogen. Available online at https://www.irena.org/-/media/Files/IRENA/Agency/Collaborative-Frameworks/IRENA_Enabling_Measures_Roadmap_for_Green_H2_Jan22.pdf, checked on 6/3/2025.

IRENA (2023): GREEN HYDROGEN FOR SUSTAINABLE INDUSTRIAL DEVELOPMENT. A POLICY TOOLKIT FOR DEVELOPING COUNTRIES. Available online at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Feb/IRENA_UNIDO_IDOS_Green_hydrogen_industrial_development_2024.pdf, checked on 10/27/2025.

IRENA (2024): Green Hydrogen Strategy. A guide to design. Available online at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Green_hydrogen_strategy_design_2024.pdf, checked on 10/24/2025.

Isabella Ankerson (2024): Uruguay's first green hydrogen plant gets funds for forestry project, 2024. Available online at https://latinlawyer.com/article/uruguays-first-green-hydrogen-plant-gets-funds-forestry-project-0, checked on 5/27/2025.

Joint SDG Fund (2023): Innovative Finance for Clean Tech Solutions in Uruguay, 2023. Available online at https://www.jointsdgfund.org/article/innovative-finance-clean-tech-solutions-uruguay, checked on 5/27/2025.

Katoen Natie (2021): Katoen Natie will invest approximately 455 million USD in the expansion of the container terminal (TCP) in Montevideo. Available online at https://www.katoennatie.com/news/katoen-natie-will-invest-approximately-455-million-usd-expansion-container-terminal-tcp-montevideo/.

LATU (2022): Lanzamiento del Fondo Sectorial de Hidrógeno Verde. Available online at https://www.latu.org.uy/noticias/lanzamiento-del-fondo-sectorial-de-hidrogeno-verde, checked on 10/24/2025.

Lucinda Elliott (2023): Uruguay plans $4 billion green hydrogen facility investment. In *Reuters Media*, 6/9/2023. Available online at https://www.reuters.com/article/business/environment/uruguay-plans-4-billion-green-hydrogen-facility-investment-idUSKBN2XU1P3/, checked on 5/27/2025.

Mapeko (2022): EL AGUA EN URUGUAY. In *Mapeko*, 8/2/2022. Available online at https://mapeko.org/recursos/agua-uruguay/, checked on 5/26/2025.

Ministerio de Ambiente (2021): 03_Datos Hidrológicos. Available online at https://www.ambiente.gub.uy/informacion_hidrica/download/Web%20Cat%C3%A1logo%20de%20Estaciones%202021/03_Datos%20Hidrol%C3%B3gicos.pdf, checked on 5/26/2025.

Ministerio de Ambiente (2025): Regiones hidrográficas. Available online at https://www.gub.uy/ministerio-ambiente/politicas-y-gestion/regiones-hidrograficas-1, updated on 5/26/2025, checked on 5/26/2025.

Ministerio de Industria, Energía y Minería (2021): Uruguay delinea una estrategia para exportar y crear un mercado local de hidrógeno verde. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/uruguay-delinea-estrategia-para-exportar-crear-mercado-local-hidrogeno-verde, updated on 5/27/2025, checked on 5/27/2025.

Ministerio de Industria, Energía y Minería (2022): H2U Program. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/politicas-y-gestion/h2u-program, updated on 6/3/2025, checked on 6/3/2025.

Ministerio de Industria, Energía y Minería (2023a): Hoja de ruta del hidrógeno verde y derivados en Uruguay. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/sites/ministerio-industria-energia-mineria/files/documentos/noticias/Hoja%20de%20ruta%20H2%20Uruguay_final.pdf, checked on 5/26/2025.

Ministerio de Industria, Energía y Minería (2023b): Uruguay's Roadmap for Green Hydrogen and Derivatives. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/sites/ministerio-industria-energia-mineria/files/documentos/noticias/H2_final-ingl%C3%A9s2020.pdf#:~:text=develop%20the%20first%20pilot%20projects,and%20innovation%20in%20this%20area, checked on 5/26/2025.

Ministerio de Industria, Energía y Minería (2024a): Hidrógeno y derivados Fondo sectorial del hidrógeno verde. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/publicaciones/fondo-sectorial-del-hidrogeno-verde, updated on 5/26/2025, checked on 5/26/2025.

Ministerio de Industria, Energía y Minería (2024b): Hidrógeno y derivados Regulación. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/politicas-y-gestion/regulacion, updated on 5/26/2025, checked on 5/26/2025.

Ministerio de Industria, Energía y Minería (2024c): Academia e investigación. Iniciativas existentes que vinculan la academia y la investigación con el desarrollo del hidrógeno y derivados. MIEM. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/politicas-y-gestion/academia-investigacion, checked on 10/24/2025.

Ministerio de Industria, Energía y Minería (2024d): I Jornada Académica en Hidrógeno Verde en Uruguay. Available online at https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/i-jornada-academica-hidrogeno-verde-uruguay, checked on 10/27/2025.

Ministerio de Industria, Energía y Minería; H2U (2024): Uruguay Energy Transition, checked on 10/24/2025.

Ministerio de Medio Ambiente (2023): Plan de Gestión Integrada del Sistema Acuífero Guaraní (PGISAG). Available online at https://www.gub.uy/ministerio-ambiente/comunicacion/publicaciones/plan-gestion-integrada-del-sistema-acuifero-guarani-pgisag, checked on 10/27/2025.

Ministerio de Medio Ambiente (2025): ÁREA EVALUACION AMBIENTAL - División Licencias Ambientales. Ref.: Belasay S.A., Planta de producción de e-Metanol a partir de hidrogeno verde – Proyecto Tambor - Tacuarembó. Available online at https://www.ambiente.gub.uy/oan/wp-content/uploads/2025/03/9.-Informe-observacion-SAAP-presentada.pdf, checked on 10/27/2025.

Ministerio de Transporte y Obras Públicas (2020): PROYECTO "FERROCARRIL CENTRAL". Informes. Available online at https://www.gub.uy/ministerio-transporte-obras-publicas/comunicacion/publicaciones/proyecto-ferrocarril-central, checked on 10/26/2025.

Ministerio de Transporte y Obras Públicas (2024): DECLARACIÓN DE LA RED FERROVIARIA. Anio 2024. Edited by Dirección Nacional de Transporte Ferroviario (pp. 5). Available online at https://www.gub.uy/ministerio-transporte-obras-publicas/sites/ministerio-transporte-obras-publicas/files/documentos/publicaciones/Declaraci%C3%B3n%20de%20Red%202024.pdf, checked on 10/26/2025.

Ministerio de Transporte y Obras Públicas (MTOP) & Administración de Ferrocarriles del Estado: Declaración de Red Ferroviaria Nacional (p. 20, Table 3). Available online at https://www.gub.uy/ministerio-transporte-obras-publicas/sites/ministerio-transporte-obras-publicas/files/documentos/publicaciones/Declaraci%C3%B3n%20de%20red%202020%20%281%29.pdf, checked on 10/26/2025.

Ministry of Economic Affairs and Climate Policy of the Netherlands (2024): RFNBO compliance analysis of products produced from renewable hydrogen and different sources of CO2 in Uruguay and Chile with the EU's Renewable Energy Directive. Final report. HINICIO. Available online at https://hinicio.com/publications/, checked on 10/23/2025.

Miro (2025): Key steps to create an Agile Roadmap: a complete guide. Available online at https://miro.com/agile/agile-roadmap/, updated on 6/3/2025, checked on 6/3/2025.

Montevideo Portal (2025): Uruguay impulsa finanzas sostenibles y trabaja en nuevos bonos verdes y azules. El país presentó en la ONU sus avances en bonos climáticos, biodiversidad y cooperación Sur-Sur. Available online at https://www.montevideo.com.uy/Noticias/Uruguay-impulsa-finanzas-sostenibles-y-trabaja-en-nuevos-bonos-verdes-y-azules-uc937717, checked on 10/24/2025.

OECD/IEA (2003): South American gas : daring to tap the bounty. Available online at https://archive.org/details/southamericangas0000unse/page/60/mode/2up, checked on 10/26/2025.

Offshore Energy (2013): GDF SUEZ to Build Uruguay LNG Terminal. Available online at https://www.offshore-energy.biz/gdf-suez-to-build-uruguay-lng-terminal/, checked on 10/26/2025.

Pakdel, Ali; Eslamloueyan, Reza (2024): Techno-economic and sustainability assessment of the power to MeOH processes: The present and future perspective. Available online at https://www.sciencedirect.com/science/article/pii/S2405844024158914, checked on 10/27/2025.

Parks, Ken (2023): Uruguay Developer Courts Energy Firms for $1.6 Billion Atlantic Coast Port. Bloomberg via EnergiesNet. Available online at https://energiesnet.com/uruguay-developer-courts-energy-firms-for-1-6-billion-atlantic-coast-port-bloomberg/, checked on 10/26/2025.

Pfennig, Maximilian; Bonin, Michael von; Gerhardt, Norman; :unav (2020): PtX-ATLAS: Weltweite Potenziale für die Erzeugung von grünem Wasserstoff und klimaneutralen synthetischen Kraft- und Brennstoffen.

Pingping, Wang; Robinson, Ada Josefina; Papadokonstantakis, Stavros (2024): Prospective techno-economic and life cycle assessment: a review across established and emerging carbon capture, storage and utilization (CCS/CCU) technologies. Frontiers. Available online at https://www.frontiersin.org/journals/energy-research/articles/10.3389/fenrg.2024.1412770/full, checked on 10/27/2025.

Portal Educativo: Acuífero Guaraní. Available online at http://www.ose.com.uy/portal-educativo/acuiferos, checked on 5/26/2025.

Product Masterclass (2024): Mastering the Product Roadmap: Essential Tips and Techniques. Available online at https://www.product-masterclass.com/blog/product-roadmap#:~:text=Regularly%20revisiting%20and%20refining%20the,stays%20ahead%20in%20the%20market, checked on 10/27/2025.

PtX Hub; DECHEMA (2024): Carbon for Power-to-X: suitable CO2 sources and integration in PtX value chains. Available online at https://ptx-hub.org/publication/carbon-for-power-to-x-suitable-co2-sources-and-integration-in-ptx-value-chains, checked on 10/31/2025.

Qassim, Ali (2025): Uruguay's green hydrogen plans raise ecological concerns in Argentina & at home. Edited by Mongabay. Available online at https://news.mongabay.com/2025/09/uruguays-green-hydrogen-plans-raise-ecological-concerns-in-argentina-at-home/, checked on 10/27/2025.

Railway Gazette International (2025): Infrastructure Uruguay sets out five-year rail investment plan. Available online at https://www.railwaygazette.com/infrastructure/uruguay-sets-out-five-year-rail-investment-plan/69751.article, checked on 10/26/2025.

REN21 (2024): Renewables 2024 Global Status Report Collection. ENERGY SYSTEMS AND INFRASTRUCTURE. Available online at https://www.ren21.net/wp-content/uploads/2019/05/gsr2024_SYSTEMS_module.pdf, checked on 5/26/2025.

Ros, Luiz (2024): Uruguay's Commitment to Climate Action: A Story of Success, 12/4/2024. Available online at https://blogs.iadb.org/sostenibilidad/en/uruguays-commitment-to-climate-action-a-story-of-success/, checked on 5/27/2025.

Sede Tacuarembó; CENUR Noreste; Unesco; Universidad de la República Uruguay (2024): Resumen Ejecutivo: Encuesta "Hidrógeno Verde y Proyecto Tambor, percepción e información de los habitantes de la zona de influencia". Available online at https://www.gub.uy/ministerio-ambiente/sites/ministerio-ambiente/files/2024-11/Anexo%205.pdf, checked on 10/26/2025.

Sieler, Roman Eric; Cames, Lisa; Schuster, Bianca; Borghardt, Sören; La Trobe, Benjamin (2021): Hydrogen Factsheet - Japan. Edited by PtX Hub. Adelphi, checked on 10/24/2025.

Siphesihle Mbatha; Raymond C. Everson; Nicholas M. Musyoka; Henrietta W. Langmi; Andrea Lanzini; Wim Brilman (2021): Power-to-methanol process: a review of electrolysis, methanol catalysts, kinetics, reactor designs and modelling, process integration, optimisation, and techno-economics. Edited by Sustainable Energy Fuels. Available online at https://pubs.rsc.org/en/content/articlelanding/2021/se/d1se00635e.

Siphesihle Mbatha; Xiaoti Cui; Payam G. Panah; Sebastien Thomas; Ksenia Parkhomenko; Anne-Cecile Roger et al. (2024): Comparative evaluation of the power-to-methanol process configurations and assessment of process flexibility. Edited by Energy Advances. Available online at https://pubs.rsc.org/en/content/articlehtml/2024/ya/d4ya00433g.

Trantor (2023): How To Create A Product Roadmap: 6 Essential Elements. Available online at https://www.trantorinc.com/blog/how-to-create-a-product-roadmap/, updated on 12/19/2023, checked on 6/3/2025.

UNIDO (2021): Innovative finance mechanism to support Uruguay's energy transition approved by Joint SDG Fund. UNIDO. Available online at https://www.unido.org/news/innovative-finance-mechanism-support-uruguays-energy-transition-approved-joint-sdg-fund, checked on 10/24/2025.

Universidad Católica del Uruguay (2024): Factores habilitantes para el desarrollo del Hidrógeno Verde en Uruguay. Infraestructura, recurso hídrico y marco normativo. Available online at https://sitio.ccu.com.uy/wp-content/uploads/2024/06/Factores-habilitantes-para-el-desarrollo-del-hidrogeno-en-UY_20240307-1.pdf, checked on 5/26/2025.

Universidad de la República Uruguay (2025a): Centro de Innovación en Ingeniería (CII): Proyectos de Innovación. Facultad de Ingeniería - Universidad de la República Uruguay. Available online at https://www.fing.edu.uy/es/noticias/area-decomunicaci%C3%B3n/centro-de-innovaci%C3%B3n-en-ingenier%C3%ADa-cii-proyectos-de-innovaci%C3%B3n, checked on 10/27/2025.

Universidad de la República Uruguay (2025b): Facultad de Ingeniería. Available online at https://www.fing.edu.uy/, checked on 10/27/2025.

Universidad de la República Uruguay (2025c): Hidrógeno: vector energético del presente y futuro | Facultad de Ingeniería. Available online at https://www.fing.edu.uy/index.php/es/node/45642, updated on 3/6/2025, checked on 10/31/2025.

Universidad de la República Uruguay (2025d): Hidrógeno como fuente de energía: tecnologías para su producción y uso. Available online at https://www.fq.edu.uy/?q=es/node/1334, updated on 6/3/2025, checked on 6/3/2025.

Universidad de Montevideo: Centro de Innovación en Organización Industrial. Universidad de Montevideo (UM). Available online at https://www.um.edu.uy/cinoi, checked on 10/27/2025.

UNIVERSIDAD TECNOLÓGICA (2025): Renewable Energies Engineering :: UTEC. Available online at https://utec.edu.uy/en/education/undergraduate-study/renewable-energies-engineering/, updated on 6/3/2025, checked on 6/3/2025.

Uruguay XXI (2024): Uruguay Takes Center Stage in Green Hydrogen at World Hydrogen Summit 2024. Available online at https://www.uruguayxxi.gub.uy/en/news/article/uruguay-takes-center-stage-in-green-hydrogen-at-world-hydrogen-summit-2024/, checked on 10/24/2025.

Uruguay XXI (2025): Green Hydrogen. Uruguay, a clean enery leader. Available online at https://www.uruguayxxi.gub.uy/en/invest/sector/energy-transition/green-hydrogen/, updated on 5/27/2025, checked on 5/27/2025.

UTEC (2025a): Renewable Energies Technology Unit. About unit. Available online at https://utec.edu.uy/en/research/technology-unit/renewable-energies-technology-unit, checked on 10/27/2025.

UTEC (2025b): Research and Innovation Group in Green Hydrogen and Electromobility. Available online at https://utec.edu.uy/en/research/research-group/research-and-innovation-group-in-green-hydrogen-and-electromobility, checked on 10/27/2025.

Veritrade (2025): IMPORTACIONES 281410: amoníaco anhidro. URUGUAY. Available online at https://www.veritradecorp.com/es/Uruguay/importaciones-y-exportaciones/amoniaco-anhidro/281410, updated on 5/27/2025, checked on 5/27/2025.

Veroslavsky; Gerardo; Manganelli, Alberto; Carrión, Roberto (2024): HIDROGENO VERDE: ENERGIA RENOVABLE y AGUA. Facultad de Ciencias de la Universidad de la República. Available online at https://www.gub.uy/ministerio-ambiente/sites/ministerio-ambiente/files/2024-11/Anexo%206.pdf, checked on 10/27/2025.

Vukasovic, Verónica; Messina, Diego (2024a): Análisis de la disponibilidad de CO2 para la producción de derivados de H2V en Uruguay. Edited by PtX Hub. GIZ, checked on 10/23/2025.

Vukasovic, Verónica; Messina, Diego (2024b): ANÁLISIS DE LAS NECESIDADES REGULATORIAS PARA EL DESARROLLO DE PROYECTOS DE PRODUCCIÓN DE HIDRÓGENO VERDE Y DERIVADOS EN URUGUAY. International PtX Hub (Messina, Diego). Available online at https://h2lac.org/wp-content/uploads/2024/03/Proyectos-h2v-y-derivados-UY.pdf#:~:text=2,generalmente%20basados, checked on 5/26/2025.

World Bank: Uruguay. Policy Options for Improving the Efficiency of Uruguay's Railway Sector. Report Number: 41884 -UY. Available online at https://documents1.worldbank.org/curated/en/675371468317093156/pdf/418840ENGLISH01eport1English1Final.pdf, checked on 10/26/2025.

World Economic Forum (2024): Accelerating the Clean Accelerating the Clean Hydrogen Economy in Latin America. Available online at https://www3.weforum.org/docs/WEF_Accelerating_the_Clean_Hydrogen_Economy_in_Latin_America_2024.pdf, checked on 6/3/2025.