IDOS | German Institute of Development and Sustainability

IDOS STUDIES 109 2026



Low-Emission Hydrogen in Uruguay and Argentina: Policy Making under Conditions of High Technological and Systemic Uncertainty

Final Report

Andreas Stamm

Rita Strohmaier

Verónica Robert

Paula Prados

Guido Bambini

Aaron Haas

Fernanda Muniz

Guido Perrone

Rebecca Rohe

Paulina Wende

CC BY 4.0 license

Low-emission hydrogen in Uruguay and Argentina: policymaking under conditions of high technological and systemic uncertainty

Final report

Andreas Stamm

Rita Strohmaier

Verónica Robert

Paula Prados

Guido Bambini

Aaron Haas

Fernanda Muniz

Guido Perrone

Rebecca Rohe

Paulina Wende

Bonn 2026

Andreas Stamm is a project lead and senior researcher in the Transformation of Economic and Social Systems department at the German Institute of Development and Sustainability (IDOS) in Bonn.

Email: andreas.stamm@idos-research.de

Rita Strohmaier is a researcher in the Transformation of Economic and Social Systems department at IDOS.

Email: rita.strohmaier@idos-research.de

Verónica Robert is a senior researcher at CONICET and a professor at the National University of San Martín (UNSAM) in Buenos Aires, Argentina.

Email: vrobert@gmail.com

Paula Prados is a professor and senior researcher at the National University of San Martín, and a specialist in Knowledge and Innovation Economy.

Email: prados.paula@gmail.com

Guido Bambini and **Guido Perrone** are researchers at the Universidad Nacional de Quilmes, Argentina. **Fernanda Muniz** is affiliated with the Universidad de la República, Uruguay.

Aaron Haas, **Rebecca Rohe** and **Paulina Wende** were postgraduate research fellows in the 59th Postgraduate Programme for Sustainability Cooperation at IDOS.

The German Institute of Development and Sustainability (IDOS) is institutionally financed by the Federal Ministry for Economic Cooperation and Development (BMZ), based on a resolution of the German Bundestag, and the state of North Rhine-Westphalia (NRW) as a member of the Johannes-Rau-Forschungsgemeinschaft (JRF).

Suggested citation:
Stamm, A., Strohmaier, R., Robert, V., Prados, P., Bambini, G., Haas, A., Muniz, F., Perrone, G., Rohe, R., & Wende, P. (2026). *Low-emission hydrogen in Uruguay and Argentina: policymaking under conditions of high technological and systemic uncertainty: Final report* (IDOS Study 109). German Institute of Development and Sustainability (IDOS). https://doi.org/10.23661/is109.2026

Disclaimer:
The analyses expressed in this paper are those of the author(s) and do not necessarily reflect the views or policies of the German Institute of Development and Sustainability (IDOS).



Except otherwise noted, this publication is licensed under Creative Commons Attribution (CC BY 4.0). You are free to copy, communicate and adapt this work, as long as you attribute the German Institute of Development and Sustainability (IDOS) gGmbH and the author(s).

IDOS Studies / German Institute of Development and Sustainability (IDOS) gGmbH
ISSN (Online) 2751-4471
DOI: https://doi.org/10.23661/is109.2026

© German Institute of Development and Sustainability (IDOS) gGmbH
Tulpenfeld 6, 53113 Bonn
Email: publications@idos-research.de
http://www.idos-research.de



Abstract

This report analyses how Argentina and Uruguay are navigating the early stages of developing a low-emission hydrogen (LEH_2) economy under conditions of high technological, economic and political uncertainty. Based on extensive fieldwork conducted in early 2024 – including 75 expert interviews and a focus group – the study examines stakeholder perceptions, national strategies, governance challenges and opportunities for value creation in both countries. The research "focuses on the question of how the main actors and stakeholders in the hydrogen economy perceive the uncertainties related to it" and how policy and international cooperation can support constructive action.

As the landscape for the international roll-out of hydrogen has changed significantly – with support measures also being adapted – it is important to better understand how stakeholders in the Global South view their prospects and what concerns they have. This study can make an important contribution in this regard. The interviews were prepared, conducted and analysed by a trilateral research team. The three institutional partners were the Universidad Nacional de Quilmes in Argentina, Universidad de la República in Uruguay and the German Institute of Development and Sustainability (IDOS). Senior researchers from Universidad Nacional de Quilmes and IDOS led the project, and the core research team comprised junior researchers from the partner institutions. The partners jointly designed the research project, arranged and conducted the interviews, and evaluated the findings and developed policy recommendations.

Globally, hydrogen demand is rising, yet the ramp-up of LEH_2 remains slow. Only 1% of global hydrogen is currently low-emission, and "the overall proportion of projects with final investment decision reached not more than 7%" of the expected production volumes by 2023. Persistently high producer prices and complex regulations (mainly at the level of the European Union) are seen as major obstacles to accelerating the roll-out of the hydrogen economy. This could change as a result of new technologies and regulatory reforms, but it is still unclear whether and when this will happen. Both Argentina and Uruguay therefore face a shifting environment: uncertain international markets, evolving certification rules and volatile investment conditions.

Argentina possesses substantial natural resources and industrial capabilities – excellent wind and solar resources for green hydrogen, major gas reserves for blue hydrogen and an established nuclear sector that could support pink hydrogen production. Its 2023 National Hydrogen Strategy envisioned integrated value chains, export markets and up to 82,000 jobs by 2050. However, the political shift in 2023 introduced institutional instability. The new government prioritises deregulation and an investment regime that offers incentives "without conditionality" and removes local content requirements. Stakeholders highlighted macro-economic volatility, grid bottlenecks and social and environmental concerns – especially water scarcity and community acceptance in Patagonia – as major barriers.

Uruguay, by contrast, benefits from long-term political consensus and a highly successful renewable energy transition, with renewables accounting for 98% of electricity generation. Its Green Hydrogen Roadmap (2022) outlines phased development towards 2040, supported by pilot projects such as H24U and Kahirós. Uruguay's competitive advantages include strong institutions, highly complementary wind and solar resources and port access. Yet large-scale projects face increasing scrutiny: Environmental authorities have delayed major proposals (e.g. Enertrag's Tambores project) due to concerns over water use, biodiversity and social licence.

In both countries, stakeholders saw export demand – especially from Europe and Asia – as the primary driver of low-emission hydrogen development. Domestic markets remain small but relevant for learning and early deployment. Opportunities for local value creation exist in engineering services; renewable energy infrastructure; carbon capture, utilisation and storage; and niche electrolyser development, but require targeted industrial policy and investment in research and development.

The report concludes that the slowdown in global hydrogen development demands realistic, “no-regret” strategies: strengthening research cooperation, developing small-scale pilot projects for domestic markets, improving environmental governance and enhancing regional collaboration (e.g. through CertHiLAC, the Clean Hydrogen and Low Emissions Certification System in Latin America and the Caribbean, the emerging Latin American certification scheme). Transparent communication, early community engagement and co-benefits for local populations are essential to avoid stranded assets and secure social legitimacy for the hydrogen transition. While this conclusion is valid for many interventions supporting the sustainability transition, it is particularly relevant to the scale-up of hydrogen production, as unrealistically high expectations have long been promoted, including by Germany as a potential buyer in its engagement with potential exporters such as Argentina and Uruguay.

Contents

Abstract

Abbreviations

1 Introduction 1

1.1 A brief outline of the issue in its international context 1

1.2 Structure of the report 4

2 National hydrogen policies 6

2.1 Hydrogen policy in Argentina 6

2.2 Hydrogen policy in Uruguay 10

2.3 Hydrogen projects in Argentina and Uruguay 14

3 Research focus, research design and stakeholders surveyed 17

3.1 Research design and methodology 17

3.2 Stakeholders interviewed 18

3.2.1 Stakeholders interviewed in Argentina 18

3.2.2 Stakeholders interviewed in Uruguay 20

4 Analysing framework conditions, uncertainties, stakeholders' interests and hydrogen policymaking 21

4.1 Argentina 21

4.1.1 Techno-economic framework conditions and H_2 production routes 21

4.1.2 Opportunities for local value creation and for the domestic market 22

4.1.3 Environmental and social issues 24

4.1.4 Political, regulatory and institutional aspects 26

4.2 Uruguay 28

4.2.1 Techno-economic framework conditions and hydrogen production routes 28

4.2.2 Opportunities for local value creation and for the domestic market 30

4.2.3 Environmental and social issues 31

4.2.4 Political, regulatory and institutional aspects 32

5 Summary and recommendations for national policy and international cooperation 33

5.1 Changes and continuities in the political settings 33

5.2 Conclusions for national policies, regional and international cooperation 35

References 39

Appendix: Extract from an interview guideline (example for chambers of commerce in Argentina) **42**

A1 Introduction (brief description of the project and its objectives) 42

A2 Informed consent: data collection and management procedures 42

A3 Interviewee background 42

A4 The low-emission hydrogen sector from a national and international perspective 42

A5 Value chain opportunities 43

A6 Challenges and uncertainties 43

A7 Role of government 43

A8 Role of international cooperation 44

A9 Closing the conversation 44

Figures

Figure 1: Overview of stakeholders interviewed by sector (Argentina) 19

Figure 2: Overview of stakeholders interviewed by sector (Uruguay) 20

Tables

Table 1: Energy-related policies and institutional reforms in Uruguay after 1990 11

Table 2: Hydrogen-related projects in Argentina 15

Table 3: Hydrogen-related projects in Uruguay 16

Boxes

Box 1: The H24U hydrogen project 12

Box 2: Industrial development and the scientific and technological system in Argentina 24

Box 3: Main features of Argentina’s provinces regarding energy and industrial projects 26

Box 4: Towards a regional certification scheme for low-emission hydrogen: CertHiLAC 27

Box 5: Recent conflicts around two large green hydrogen projects in Uruguay 32

Abbreviations

AHK	German Chambers of Commerce Abroad / Außenhandelskammer
ALUR	Alcoholes del Uruguay
ANCAP	National Administration of Fuels, Alcohols and Portland Cement / Administración Nacional de Combustibles, Alcohol y Pórtland
BH_2	blue hydrogen
BMFTR	German Federal Ministry of Research, Technology and Space / Bundesministerium für Forschung, Technologie und Raumfahrt
CCUS	carbon capture, utilisation and storage
CertHiLAC	Certification System for Clean and/or Low-Carbon Hydrogen and its Derivatives in Latin America and the Caribbean
CO_2	carbon dioxide
CONICET	National Scientific and Technical Research Council / Consejo Nacional de Investigaciones Científicas y Técnicas
ESIA	environmental and social impact assessment
EU	European Union
FhG	Fraunhofer Society for the Advancement of Applied Research
FID	final investment decision
FLH	full-load hours
GHG	greenhouse gas
GH_2	green hydrogen
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	gigawatt
H_2	hydrogen
IDB	Inter-American Development Bank
IIBCE	Clemente Estable Biological Research Institute / Instituto de Investigaciones Biológicas Clemente Estable
INTI	National Institute of Industrial Technology / Instituto Nacional de Tecnología Industrial
kg	kilogram
LEH_2	low-emission hydrogen
MERCOSUR	Mercado Común del Sur
MIEM	Ministry of Industry, Energy and Mining / Ministerio de Industria, Energía y Minería
MoU	Memorandum of Understanding
Mt	million tonnes
MW	megawatt
NDC	Nationally Determined Contribution
NHS	National Hydrogen Strategy
OLADE	Latin American Energy Organisation / Organización Latinoamericana de Energía

PEELP	Long-Term Strategic Export Projects / Proyectos de Exportación Estratégica de Largo Plazo
PH_2	pink hydrogen
PTB	German Metrology Institute / Physikalisch-technische Bundesanstalt
R&D	research and development
RE	renewable energy
RFNBO	renewable fuel of non-biological origin
RIGI	Incentive Regime for Large Investments / Régimen de Incentivo para Grandes Inversiones
SAF	sustainable aviation fuel
SMR	steam methane reforming
SSA	Secretariat for Strategic Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States dollar
UTE	Uruguayan Electricity Company / Administración Nacional de Usinas y Trasmisiones Eléctricas
WH_2	white hydrogen

1 Introduction

This report is based on research carried out in early 2024 by a research team working within the IDOS postgraduate programme. An innovative aspect of the research team was that it brought together not only participants from the institute's postgraduate programme but also post-graduate students from Argentina and Uruguay on an equal footing. The project was led by two researchers from IDOS and one researcher each from Universidad Nacional de Quilmes and Universidad Nacional de General San Martín. The research focused on a topic that has been of great interest to Germany, Argentina and Uruguay in recent years: the question of whether a swift transition to an internationally coordinated hydrogen (H_2) economy can not only contribute to climate change mitigation through industrial decarbonisation but also offer new opportunities for creating value and employment.

1.1 A brief outline of the issue in its international context

Decarbonising the global economy is crucial to limiting climate change, ensuring that future generations can live in acceptable conditions and reducing harm to people and nature. Limiting global warming to no more than 2 degrees Celsius above the pre-industrial average temperature implies that emissions of CO_2 and other greenhouse gases (GHGs), for example methane, must be drastically reduced in a very short time. Electrifying industrial processes and transport is the primary technological option for decarbonisation where electricity is generated from renewable energy sources. However, there are processes that are not suitable for direct electrification. This applies to industries that require high process temperatures, for example the iron, steel and chemical industries, and to heavy-duty and long-distance road, rail and air transport. In these cases, H_2 is an important energy carrier and, in some industrial processes, a feedstock.

In 2024, around 100 million metric tonnes (Mt) of H_2 were used globally (IEA [International Energy Agency], 2025, p. 32). By far the largest share of it was produced from fossil fuels, for example via steam methane reforming (SMR) using natural gas or via coal gasification. Both routes produce substantial GHG emissions. Thus, using H_2 in industry and transport is not inherently sustainable; rather, global hydrogen production currently generates emissions of 920 $MtCO_2$/year (IEA, 2024, p. 203). Low-emission hydrogen (LEH_2) production has grown marginally in recent years and remains below 1 Mt per year – accounting for only around 1% of global hydrogen production (IEA, 2024, pp. 60-61).

Based on the specific production routes, the literature distinguishes between the following hydrogen "colours":

- *black hydrogen* is H_2 produced from black coal (bituminous coal) through coal gasification;
- *brown hydrogen* is H_2 produced from lignite, also known as brown coal, through coal gasification;
- *grey hydrogen* is H_2 produced from natural gas through SMR;
- *turquoise hydrogen* is H_2 produced through methane pyrolysis, a process that splits methane (CH_4) into H_2 and solid carbon;
- *blue hydrogen* (BH_2) is produced in the same way as grey hydrogen but the resulting CO_2 is captured, used[1] or stored permanently, for example in caverns or depleted gas fields;

1 For instance, to produce synthetic fuels or feedstock in the chemical industry, including fertiliser production.

- *green hydrogen* (GH_2) is produced through the electrolysis of water using electricity from renewable energy (RE) sources, with pure oxygen as a by-product;
- *pink hydrogen* (PH_2) is also produced through electrolysis using electricity from nuclear power;
- *white hydrogen* (WH_2) is naturally occurring H_2 found in Earth's crust.

Current discussions focus on emission-intensive black, brown and grey hydrogen and low-emission blue and green hydrogen. Some experimental projects for pink hydrogen production are currently under way in the United States, France, Japan and South Korea. Turquoise hydrogen has not yet reached a sufficiently high technological readiness level to be currently relevant, and deposits of WH_2 large enough to warrant consideration of commercial exploitation have only recently been detected.

The relative importance of the various types of H_2 today is clearly defined: Emission-intensive hydrogen dominates industrial use: around 60% is grey hydrogen and 20% is black hydrogen. In addition, more than 15% of global hydrogen production is produced as a by-product in refineries and the petrochemical industry from processes such as naphtha reforming. Low-emission hydrogen production (BH_2 and GH_2) has grown marginally in recent years and remains below 1 Mt per year, accounting for only around 1% of global production (IEA, 2024a, pp. 60-61). However, scaling up low-emission hydrogen production and expanding international trade are the focus of around 65 hydrogen strategies approved by governments around the world (IEA, 2025, p. 205).

In terms of the carbon footprints of the two types of LEH_2, GH_2 is considered superior to BH_2, as it is practically impossible to capture all the CO_2 generated through SMR and to eliminate upstream methane leakage entirely, as it is a powerful GHG. On the other hand, electrolytic hydrogen is not necessarily carbon-free and can only be classified as "green" if the electricity is generated exclusively from renewable sources such as hydropower, wind, solar or geothermal energy. If the electrolysers are powered by grid electricity, then the carbon footprint of the H_2 produced necessarily depends on the grid's electricity generation mix. Plans to produce GH_2 that complies with the European Union's (EU) strict zero-emission criteria, for example, are therefore often based on projects in which the electrolysers are to be powered by electricity from dedicated renewable energy generation plants ("off-grid" or "behind-the-meter" hydrogen).

The EU applies an extremely strict definition of renewable hydrogen, for example requiring that the electricity used for electrolysis come from new renewable energy capacity rather than existing installations and that renewable electricity generation and hydrogen production must occur within the same time window (hourly or monthly, depending on the phase-in period). In addition, the renewable electricity source must be located in the same bidding zone or same directly connected zone as the electrolyser (European Commission, s.a.-a).

In Germany, which has been committed to using H_2 to support decarbonisation for several years, the discourse has changed significantly over this period. Whereas the 2020 National Hydrogen Strategy (BMWI, 2020) focused exclusively on GH_2, the 2023 update (BMWK, 2023) mentions BH_2 and presents it as a transition technology.

Only recently has WH_2 appeared on the international energy agenda. This followed discoveries of significant reservoirs of natural hydrogen in countries such as Mali and Albania (Aimikhe & Oghenegare, 2023). White hydrogen pilot projects have been documented in several regions of the world (IEA, 2025, pp. 190-191). Whether and when WH_2 can be commercially used at scale is uncertain and requires substantial further basic and applied research.

In recent history, H_2 has attracted successive waves of interest, yet none of these has resulted in a sustained and substantial increase in investment beyond traditional industries, mainly in refining and chemical production (IEA, 2019, pp. 17-19). What sets the current trend apart is the

extensive exploration of potential new hydrogen applications and low-emission production processes. This change in perspective is making H_2 a prominent topic in mainstream energy discussions globally, with various nations and companies recognising its potentially valuable role in the future of energy (IEA, 2019, pp. 17-19).

Based on its analysis of current government policies and announcements, the IEA (2024, p. 21) anticipated that hydrogen demand could reach between 115 and 130 Mt by 2030, with favourable prospects for LEH_2. Recently, however, international discourse on H_2 has become increasingly sceptical, reflecting empirical findings. For instance, the IEA's "Global Hydrogen Review 2023" (IEA, 2023, p. 50) stated that the "pipeline of announced projects for the production of low-emission hydrogen accounts for up to 38 Mt by 2030" (IEA, 2023, p. 50). However, at that time and in most cases, non-binding Memorandums of Understanding (MoUs) had been signed; only 4% of this projected production had reached a final investment decision (FID). In 2024 and 2025, the IEA's "Global Hydrogen Reviews" presented mixed findings. The quantities of LEH_2 for which an FID has been reached increased substantially, mainly in Europe and North America. Still, projects that had reached FID accounted for no more than 7% of projected green hydrogen production in 2030. Most projects are still at the planning stage or earlier stages of development (IEA, 2024a, p. 9).

In recent publications assessing the state of the hydrogen economy, the concept of "uncertainty" features prominently. For instance, in the IEA's "Global Hydrogen Review 2024", the terms "uncertainty" and "uncertainties" are mentioned 30 times, compared with 44 times in the 2025 edition. Sometimes the uncertainty concerns the future of announced projects; in most cases, however, uncertainties are seen as major barriers to the ramp-up of a low-emission hydrogen economy. The uncertainties refer most often to "regulatory uncertainty"; unclear prospects for cost reductions; the question of whether hydrogen demand will reach projected levels; and if and when complementary elements of the hydrogen economy will be established. It is important to note that these forms of uncertainty should not be equated with risk. Various schools of economic thought (Keynes, post-Keynesianism, Knight) clearly distinguish between risk and uncertainty and their impacts on economic development. Risk refers to unknown outcomes with *known* probabilities, whereas uncertainty refers to situations in which the future is fundamentally unknowable and no meaningful probability distribution can be assigned to future events (e.g. Shackle, 1949). The ramp-up of a global low-emission hydrogen economy is marked by multiple open and unknowable "futures" – or as RAND characterises the situation regarding the required transition to sustainable development: "deep uncertainty" (RAND, s.a.).

When people, companies and policymakers are faced with situations in which they have to make decisions while experiencing deep uncertainty, they often draw successfully on *experiential* instead of *analytical* knowledge (Lempert, Popper, & Bankes, 2003, p. 4). When it comes to the hydrogen economy, however, experience-based knowledge is limited and cannot help much with decision-making.

The concepts of "uncertainty" and "deep uncertainty" form the heuristic basis for the present study. It focuses on the question of how the main actors and stakeholders in the hydrogen economy perceive the uncertainties related to it, and which policies and modes of international cooperation might enable them to implement constructive action in their countries. The motivation behind the study was that, even though the high expectations of a rapid ramp-up of a global hydrogen economy have given way to a more sober assessment, solutions are still needed to decarbonise energy-intensive activities that cannot be directly electrified. Examples include the steel industry, refineries, and heavy-duty and long-distance transport. LEH_2 and its derivatives (ammonia, methanol, sustainable aviation fuel – SAF) remain instruments of choice.

In the study, we adopted an inductive approach, meaning that we did not formulate ex ante hypotheses regarding the uncertainties faced by decision-makers and stakeholders in the hydrogen economy in Argentina and Uruguay in order to ask interviewees to rank or weight

those uncertainties. Given the novelty and complexity of the topic, we decided it was necessary first to *understand* how the ramp-up of a hydrogen economy is perceived in the specific spatial, temporal and social context of the debate before drawing more general conclusions. After several years of IDOS research on H_2 (www.hypat.de), we already had a preconception of which types of uncertainty we might find and which not. The core technology of water electrolysis is well-established internationally; the underlying chemical principles have been understood for roughly two centuries. This does not mean, however, that there are no uncertainties related to the production of LEH_2. Even where technologies have achieved high levels of technological readiness, uncertainties remain about the operation of different electrolyser technologies under varying conditions, for example under extreme climate conditions (very hot or very cold ambient conditions) or using different renewable electricity sources to power the facility that allow shorter, longer or permanent periods of operation.

In addition, technical uncertainties remain at several other stages of low-emission hydrogen value chains as well. For instance, for long-distance transport of H_2, ammonia and methanol synthesis are currently seen as the most promising routes to produce products with higher energy density that are easier to store than elemental hydrogen. Whereas ammonia and methanol synthesis are considered fully mature industrial technologies, this is not the case for ammonia and methanol cracking if elemental hydrogen is required at the destination port**.** The same holds true for direct air capture of CO_2 – required for the production of synthetic fuels – which is described as a “proof of concept” investment at the most advanced e-fuels facilities in Latin America, implemented by HIF Global in southern Chile (HIF Global, 2025). Anecdotal evidence suggests that technological uncertainties grow as the scale and complexity of projects increase.

In developing a global hydrogen economy, economic uncertainties appear to be at least as relevant as technological ones. In the past two years, for example, several large H_2 projects along the value chain have been substantially delayed, scaled back or cancelled altogether. Examples include several hydrogen projects at refineries in Spain, the construction of a hydrogen pipeline between Norway and Germany, and the transition from blast furnaces to direct reduction plants based on H_2 at ArcelorMittal’s steel plants in Germany (Fuel Cells Works, 2025). The difficulties facing the hydrogen market largely reflect the fact that production costs for LEH_2 have not fallen as much as most national strategies had projected just a few years ago. This makes industrial energy users reluctant to move towards a low-emission hydrogen–based decarbonisation of their production plants. This, in turn, raises questions about whether investments in large-scale hydrogen production and logistics projects (such as pipelines and port infrastructure) have a promising business case.

1.2 Structure of the report

Section 2 outlines hydrogen policies in the two case-study countries. Both countries approved hydrogen strategies in the past few years. They have several features in common but differ significantly in others. We give an overview of the strategies and policies and describe in detail the projects that are currently being planned or (in a few cases) implemented. We updated this section because quite some time has passed since the empirical work of the research was finalised. The study highlights important differences between the countries. Whereas Uruguay has a strong renewable energy sector, which could be further expanded to produce LEH_2, Argentina has natural resources that offer a choice between GH_2 and BH_2. Argentina has a relatively advanced manufacturing sector that could support value creation within a hydrogen economy, whereas neighbouring Uruguay has a less developed manufacturing base. In Uruguay, energy policies have been based on a broad political consensus for approximately two decades. This includes a substantial energy transition away from imported fossil fuels and a significant expansion of wind power generation. A more stable political setting might offer better

prospects for developing a low-emission hydrogen economy. The main measures shaping the political conditions for developing this economy are outlined in Section 2 alongside lists of projects planned as early as 2026.

Section 3 describes the specific focus of the research project and the methods developed and applied in close cooperation with partners in both Argentina and Uruguay. Because the ramp-up of a low-emission hydrogen economy in Latin America is not yet a reality that can be assessed ex post with quantitative or qualitative methods, the research focused on past and ongoing actions related to a hydrogen economy and the opportunities and risks perceived by stakeholders. From the earliest stages of preparation onwards, it was clear that *uncertainty* was high – in practice and in stakeholders' perceptions – and that it might influence or reduce willingness to invest financial and human resources in the low-emission hydrogen economy. To capture these partly interrelated uncertainties, the partners involved agreed that semi-structured interviews were the most promising method and sought to include a broad range of interviewees, including policymakers, policy implementers and representatives of public and private enterprises, business associations, chambers of commerce, and international and development cooperation organisations. A focus group discussion in one region directly affected by a planned green hydrogen project captured the views of local populations and NGOs.

Section 4 presents the core analysis of our research in Argentina and Uruguay. The key findings were grouped retrospectively into four thematic areas that proved to be particularly relevant in both countries. First, the respective techno-economic starting conditions are outlined, along with the possible production pathways that arise from them (4.1.1; 4.2.1). Of particular relevance to the producer countries are the opportunities arising for local value creation and for the domestic use of hydrogen technologies (4.2.2). These opportunities must be weighed against possible environmental and social risks, which are also of great significance for the acceptance of a hydrogen economy (4.1.3 and 4.2.3). Given the considerable uncertainties surrounding the hydrogen economy, the political, regulatory and institutional governance of the emerging hydrogen economy is of great importance. These issues are outlined in the concluding sections of Section 4 (4.1.4 and 4.2.4).

The concluding **Section 5** is divided into two parts. In Section 5.1 the key findings are summarised and placed in the context of changes that have occurred since the fieldwork was completed. As hydrogen policy is a highly dynamic area, this update was essential. Section 5.2 offers a number of policy recommendations for national governments and international cooperation partners, including Germany's support activities. This section of the report has benefited specifically from the trilateral cooperation between Germany, Argentina and Uruguay. Stakeholders with extensive experience in evidence-based policy advice were involved from all three countries. Given the high level of uncertainty, it was necessary to consider how to proceed in order to capitalise on potential opportunities. At the same time, responsible policy recommendations must be formulated to minimise the risk of costly project failures or "stranded assets".

2 National hydrogen policies

The fieldwork for the study was finalised in May 2024. As the policy area is evolving rapidly, the following section was updated at the end of 2025 and in early 2026 to ensure that it is still up-to-date and the empirical findings are well represented.

2.1 Hydrogen policy in Argentina

Argentina's hydrogen policy shifted following the change of government in December 2023. During the previous administration, the policy aimed to develop the hydrogen economy across the entire value chain, taking advantage not only of the country's natural resources but also of its scientific, technological and industrial capabilities, especially in the chemical and petrochemical sectors and in the domestic suppliers to the oil and gas sector. Until the change of government, the policy was structured along three main areas:

- the development of a National Hydrogen Strategy (NHS) and its action plan through a participatory process involving a dialogue forum for public and private actors;
- the implementation of a strategic environmental assessment of the policy to guarantee the sustainability of this emerging sector; and
- the submission of a bill to Congress to promote the hydrogen economy with tax incentives and local content requirements.

Alongside this policy framework, different political groups promoted alternative bills that supported only GH_2 and omitted local content requirements.

The new government under President Javier Milei has not yet articulated a clear policy on H_2, but in line with the alternative bills, it opposes local content requirements, other rules and the creation of institutions to regulate the sector. Although it has not proposed an alternative hydrogen bill, the Incentive Regime for Large Investments (RIGI) is seen by different actors in the sector as a potential tool to promote hydrogen projects. The main attributes of this regime are market freedom and the provision of benefits without conditionality.

The tensions and differences between the hydrogen policies promoted by the previous administration and the current one demonstrate competing development models – one placing greater emphasis on industrial policy and another advocating the primacy of markets over development planning. These swings in national policy on H_2 were identified by interviewees as a specific source of uncertainty: *institutional instability* that emerges from a lack of consensus on the sector's development.

National Strategy for the Development of a Hydrogen Economy 2023 and Action Plan

In 2023, Argentina's Secretariat for Strategic Affairs published a comprehensive strategy paper on LEH_2, the "National Strategy for the Development of a Hydrogen Economy 2023–2050" (SSA [Secretariat for Strategic Affairs], 2023). With this paper, the government signalled its commitment to a greener future. Based on the country's substantial renewable energy potential, mainly wind and solar, and its natural gas resources, the NHS went beyond mere production. It envisioned a holistic ecosystem encompassing research, development, infrastructure and international cooperation. Cooperation with international partners, including the Southern Common Market (Mercado Común del Sur – MERCOSUR), and investment in technological advancements were seen as key elements supporting this endeavour. The strategy's approach extended beyond energy production and aimed to integrate H_2 into various sectors. In addition, it included the entire value chain, from equipment for renewable energy generation to the production of

hydrogen derivatives that could be applied to current and future uses such as fertilisers (SSA, 2023, p. 11). Argentina's strategy also included the blue and pink hydrogen economy because the country is considered to have substantial potential, given its large gas reserves and extensive experience in nuclear research and nuclear energy use.[2]

Furthermore, Argentina's strategy emphasised inclusiveness and economic growth. The development of a robust hydrogen economy was envisaged as a catalyst for job creation: projections indicated 13,000 jobs by 2030 and 82,000 jobs by 2050; 44% of these jobs would be indirect employment and 56% direct.[3] Technological innovation and improved coordination between secondary, technical and higher education institutions were seen as prerequisites for developing the training pathways required by the industry (SSA, 2023, p. 41).

The SSA estimated that competitive prices for locally produced LEH_2 would be achieved after 2030. Estimated costs for BH_2 might range between USD 1.10 and USD 2.10 per kilogram (kg), depending on natural gas prices. Green hydrogen costs might range between USD 2.80 and USD 6.40 per kg, depending on the quality and accessibility of renewable resources in different regions. Patagonia currently offers the greatest potential competitiveness because of its wind capacity factor, which can reach 60% in some locations (Dean, 2025). Argentina aims to compete more effectively in the global market, particularly in long-distance trade. By leveraging its expertise in chemical production and management – coupled with established port infrastructure in Bahía Blanca, which is dedicated to this trade – Argentina seeks early entry into the international hydrogen market (SSA, 2023, p. 21). Within the NHS, the Secretariat for Strategic Affairs emphasised Argentina's competitive advantages, forecasting exports of 0.3 Mt per year from 2030 onwards and a 5% share of the global market by 2050. This would correspond to production of at least 4 Mt per year (SSA, 2023, p. 24).

When it comes to the domestic use of H_2, Argentina produced 0.4 Mt of grey hydrogen for domestic consumption in 2023, representing 9% of the Latin American market (4.4 Mt) and approximately 0.4% of worldwide demand (94 Mt in 2023). To minimise transport and storage costs, production facilities are projected to be strategically located near consumption hubs. Domestic production serves various end uses, including the manufacture of fertilisers, methanol for the iron and steel sector, fuel refining and other chemical industries. The strategy projects that domestic demand for LEH_2 will rise steadily from 2030 onwards, estimated to reach 100,000 tonnes annually by 2035. Anticipated growth forecasts indicate a surge to 500,000 tonnes per year by 2045 and a substantial increase to 1 Mt per year by 2050. To meet this demand, a portion of the local supply will come from domestically produced BH_2. This domestic production will play a vital role in enhancing conditions for larger-scale initiatives and thus facilitate Argentina's participation in export markets (SSA, 2023, p. 28).

In the short term, Argentina aims to leverage its renewable energy sources, such as wind and solar, as well as its natural gas to produce GH_2 and BH_2. Argentina also envisages becoming a global leader in pink hydrogen production, based on its technological capabilities in the nuclear sector. Argentina's three operational nuclear reactors currently account for 9% of electricity generation (World Nuclear Association, 2026). The NHS focused on a fourth reactor (CAREM25), a small modular reactor developed entirely in Argentina.

In addition to the NHS, Argentina proposed an Action Plan, which focused on five areas: development of local suppliers, regulatory enablers (including certification), training and capacity building, infrastructure and identification of sources of domestic demand (SSA, 2023, p. 12).

2 The first Argentinian nuclear reactor went into operation in 1974 (Merke, 2016, p. 16).

3 Direct employment refers to jobs directly linked to the core operations of an industry, while indirect employment concerns those generated by the industry's broader economic activities.

Strategic environmental assessment

The strategic environmental assessment was the *second* main area of the policy and aimed to provide a sustainability framework for the NHS, based on information about environmental and social conditions in the areas where hydrogen projects were to be carried out. The assessment covered green (wind energy) and blue technologies in the region of Patagonia and in the southern part of the Province of Buenos Aires, as they were the most likely to be deployed in the short to medium term. The work involved the systematisation of information to identify social and environmental risks and the development of a series of participatory workshops in different locations to collect information from the community. The findings showed that even with critical environmental areas protected, the potential to produce GH_2 and BH_2 is substantial due to the extensive areas suitable for generating LEH_2. In the participatory workshops, it became clear that participants were optimistic about hydrogen projects because of their contribution to climate change mitigation. One concern was that hydrogen projects were not sufficiently integrated into local industrial infrastructure. This raised concerns that the hydrogen economy might simply reproduce traditional extractive models of supply chains.

Regulatory framework: hydrogen bills

The *third* main area of the policy centred on a bill to promote the hydrogen economy, submitted to the National Congress by the Ministry of Industry, Energy and Mining (MIEM). It is important to highlight that Argentina already had a legislative precedent in Law 26.123[4] promoting LEH_2. It was approved in 2006 and expired in 2021. Although this law was not implemented, its approach to H_2 was pioneering, as it promoted a framework to establish research and technology teams focused on the hydrogen economy, envisaging H_2 as an energy carrier for storage and use in transport, emphasising regional cooperation in particular.

The 2023 bill was broader in scope than previous legislation had envisioned and its projections were updated to reflect current conditions. It included a series of fiscal benefits, fiscal stability for 30 years and measures creating benefits for access to the foreign exchange market. The latter is particularly relevant for export-oriented and capital-intensive projects that depend on access to foreign currency to repay loans and finance imports. The bill, consistent with the strategy and environmental assessment, focused on LEH_2, including benefits for green, blue and pink hydrogen. Consistent with the industrial policy approach at the time, access to benefits would be conditional on compliance with local content requirements, which are intended to integrate projects more closely into domestic production networks and support local supplier development. Finally, the bill also called on investors to carry out research and development (R&D) in the country and involved them in the creation of institutions to promote and regulate the sector; for example by developing standards for safety, quality and certification of origin.

Different political parties proposed alternatives to the executive branch bill. These bills were indicative of internal disputes and how different groups envisioned the hydrogen sector's development. These alternative bills offer similar benefits for projects, but they differ in that they impose neither local content nor R&D requirements and do not promote the establishment of institutions to regulate this emerging sector.

Currently, there are three bills being processed by congressional committees that were introduced by different political parties. These are:

1. Draft framework bill for the renewable hydrogen and low-emission hydrogen industries and their derivatives (*Proyecto de ley de marco regulatorio para la industria del hidrogeno de origen renovable y de bajas emisiones y sus derivados*) (Senado Argentina, 2024);

4 Ley 26.123 "Promoción del Hidrógeno" (Ministerio de Justicia Argentina, 2006).

2. Regulatory framework for the renewable hydrogen and low-emission hydrogen industries and their derivatives (*Marco normativo para la industria del hidrógeno de origen renovable y de bajas emisiones y sus derivados*) (Diputados Argentina, 2024);

3. Regulatory framework for promoting investment in the renewable hydrogen and low-emission hydrogen industries and their derivatives (*Marco normativo para la promoción de inversiones para la industria del hidrógeno de origen renovable y el hidrógeno de bajas emisiones y sus derivados*) (Diputados Argentina, 2025).

The three bills largely represent the interests of investors and other parties involved in the hydrogen economy. These include chambers of commerce for renewable energies and the German Chambers of Commerce Abroad (AHK), among others. These stakeholders are brought together within the civil organisation “Plataforma H2Ar”.

Bills 1 and 2 are similar: They propose differentiated tax incentives depending on whether the hydrogen is green or low-emission and they establish governance responsibilities for the energy secretariat. While they do not require local content, they prioritise incentives for investment projects that include it. In contrast, bill 3 focuses on extending the RIGI accession window for investment projects in the low-emission hydrogen value chain to five years. All bills reflect a conventional approach to promoting foreign direct investment with no local content requirements, or only weak ones.

The new government and its Incentive Regime for Large Investments

In the 2023 general elections, Javier Milei of La Libertad Avanza (“Liberty Advances”) was elected president of Argentina. This political movement was formally established as a rather loose alliance of conservative and libertarian parties to stand in the 2021 Argentine legislative election. After winning the elections in 2023, a party of the same name was formed. Javier Milei strongly shapes the ideology of Libertad Avanza. The party takes conservative positions on social issues and libertarian positions on economic issues. His radical stance is evident in the fact that Milei calls himself an “anarcho-capitalist” and uses the chainsaw (with which he wants to destroy traditional institutional structures) as an important symbol of his administration (Zilla, 2023).

One of the new government’s first measures relevant to this study was an investment promotion policy consistent with a free-market approach: RIGI. Although it is not specifically designed for H_2, it appears to be tailored to industries with similar characteristics, including a high cost of capital and long maturation periods for investments. Various interviewees saw RIGI as providing the incentives necessary to develop the hydrogen economy in Argentina; others maintained that it was not enough and that hydrogen projects would require longer timeframes than those available under RIGI, together with additional incentives.

To date, RIGI is the most important scheme for promoting large-scale investment introduced by the Argentine government. It applies to investments of USD 200 million or more in eight business sectors: forestry, tourism, infrastructure, mining, technology, steel, energy, oil and gas. RIGI offers tax, customs and foreign exchange benefits and does not link these benefits to specific requirements for the beneficiary company, for example in terms of local content requirements or technology transfer. On average, the tax benefits provided for in RIGI exceed those provided for in previous bills, and it also provides greater access to the foreign exchange market, allowing proceeds from hydrogen exports to be deposited directly in accounts abroad.

Large hydrogen projects could also qualify as Long-Term Strategic Export Projects (PEELP) under RIGI, requiring a minimum investment of USD 2 billion. Qualifying as a PEELP grants additional incentives, including a shorter period before export proceeds become fully and freely

available – reaching 100% after three years instead of four – and a specialised tax stability guarantee that protects the project from any increases in local or municipal taxes for 30 years.

A key aspect of RIGI is its dispute resolution mechanism, which prioritises international arbitration for disputes between investors and the Argentine government. While the proponents of RIGI see this as a mechanism to ensure a neutral and potentially efficient process, critics argue that this could undermine Argentina's judicial sovereignty, as it allows foreign investors to bypass domestic courts. Some of these benefits can be understood as a strategy to shield investment projects from Argentine systemic risk amid severe macroeconomic difficulties. This is consistent with the "derisking" policies promoted by different international financial institutions.

RIGI is applicable throughout Argentina and declares investments admitted to the regime as being of national interest. While it does not prioritise sectors, it originally stipulated a two-year application window from the regime's entry into force, with the option of a one-year extension. The National Executive Branch has already exercised this option, establishing July 2027 as the application deadline. The application window appears short. Investment decisions on hydrogen projects remain uncertain and may take longer to finalise.

The incentives under RIGI reduce the total tax burden and ease foreign exchange restrictions. The benefits for investors are substantial compared with those available under other investment promotion schemes. In return, there is no requirement to develop local suppliers or transfer technology. There is also no obligation to supply a specified share of production to the domestic market. The first project approved under RIGI is El Quemado Solar Park in Mendoza Province, established by YPF Luz in collaboration with EMESA (Mendoza Energy Company) with a planned capacity of 305 megawatts (MW) (YPF Luz, s.a.). Subsequently, several projects were approved mainly in the oil, gas and mining sectors (gold, copper and lithium), along with another project for renewable energy generation (wind). No projects were approved in the hydrogen sector.

2.2 Hydrogen policy in Uruguay

One year after general elections in Argentina, neighbouring Uruguay also went to the polls (October 2024 – runoff November 2024). Unlike in Argentina, the change of governing party (Frente Amplio to Partido Nacional) did not lead to a radical change in hydrogen policy or related energy and environment policies. Uruguay has an established tradition of peaceful changes of government and – unlike in some other Latin American countries – a change of governing party usually does not mean that existing policy processes are abandoned or substantially revised. In relation to energy policy, the literature stresses that the energy transition, which began in 2008, was based on a multiparty agreement, which partly explains its success (Casaravilla & Chaer, 2021, p. 14; Ponce, 2024).

In terms of democratic stability, international comparisons rank Uruguay very high. For instance, the Economist Intelligence Unit's (EIU) democracy index classifies Uruguay as one of only two "fully democratic" countries in Latin America, ranking it 15th globally. The Bertelsmann Transformation Index (BTI) – a measure of democracy in developing or transitional economies – ranks Uruguay second for governance and first for political transformation among the countries it assesses (McNamara, 2025, p. 1).

Table 1 summarises the main policies and institutional reforms relevant to the energy sector and the hydrogen economy in Uruguay.

Table 1: Energy-related policies and institutional reforms in Uruguay after 1990

Reference year	Policies and institutional reforms	Core content and relevance to GH_2
1990	Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente (MVOTMA)	MVOTMA's mission was to integrate housing policy, land-use planning and environmental protection under one institutional umbrella.
1994	Climate Change Unit of the National Directorate for the Environment at MVOTMA	MVOTMA's Unidad de Cambio Climático was tasked with developing and implementing national strategies to address climate change through both mitigation and adaptation.
2008	National Energy Policy 2005 to 2030	The National Energy Policy was endorsed between 2008 and 2010 by all parties represented in parliament. The plan set a target for renewable energy sources to account for 50% of primary energy by 2015. This includes RE for electricity generation, industrial and domestic heat, and transport.
2017	First Nationally Determined Contribution (NDC1)	NDC1 sets out a comprehensive climate strategy rooted in sustainable development, equity and human rights.
2020	Ministry of Environment (Ministerio de Ambiente)	The ministry was carved out from the former Ministry of Housing, Territorial Planning and Environment (MVOTMA), giving environmental issues a dedicated institutional home with greater autonomy and visibility.
2021	Estrategia Climática de Largo Plazo de Uruguay (Long-term Climate Strategy)	The Long-term Climate Strategy aims to achieve a low-emission and climate-resilient future; it extends the horizon to 2050 and beyond, with a strong emphasis on intergenerational equity and sustainable development.
2022	Second Nationally Determined Contribution (NDC2)	Key targets: - for the transport sector: "*By 2030, 600 hydrogen fuel cell-powered freight vehicles have been added to the fleet."* *- for the institutional setting: "By 2030, regulation, capacities and incentives have been developed within the framework of the implementation of the Green Hydrogen Roadmap"*
2022	Uruguay's Roadmap for Green Hydrogen and Derivatives	The Green Hydrogen Roadmap outlines a national strategy to develop a competitive and sustainable hydrogen economy by 2040.
2024	Third Nationally Determined Contribution (NDC3)	NDC3 reflects the country's deepened commitment to climate action for the period 2023-2035. On mitigation, NDC3 aims to strengthen efforts to reduce GHG emissions across key sectors – energy, agriculture, waste and land use. On adaptation, it aims to enhance resilience in vulnerable areas such as water resources, coastal zones, health and food systems.

Uruguay underwent a successful energy transition, beginning in the late 2000s. Between 2008 and 2015, private firms installed 581 MW of wind capacity in the country. To support the energy transition, the state offered long-term contracts to buy clean electricity at above-market rates through feed-in tariffs, determined via auctions (Bertoni & Messinan, 2023). Today, the country generates 98% of its electricity from renewable energy sources, joining a small group of high-

income countries producing more than 90% of their electricity from low-carbon sources – including Iceland, Sweden and France. Once a net importer of energy, Uruguay now exports its surplus electricity to neighbouring Brazil and Argentina (Markert, 2024).

Towards Uruguay's hydrogen roadmap

With the decarbonisation of its electricity mix regarded as largely complete, Uruguay is now pursuing the second phase of its energy transition, which would include the use of H_2 in hard-to-decarbonise sectors, such as heavy-duty and long-distance road transport, energy-intensive industries, maritime and air transport. Exporting H_2 or derivatives is also part of the agenda. In 2018, Uruguay began working on GH_2 by creating an inter-institutional working group that included MIEM and the state-owned energy companies National Administration of Fuels, Alcohols and Portland Cement (ANCAP) and Uruguayan Electricity Company (UTE). In 2021, three roundtables were attended by national and international stakeholders and had more than 70 national and international representatives at each meeting. As a result, MIEM released the "Green Hydrogen Roadmap in Uruguay" in 2022.

Box 1: The H24U hydrogen project

The winner of the Green Hydrogen Sector Fund of MIEM is led by a consortium of Saceem and CIR. Saceem is a Uruguayan company that has been working in the fields of engineering, construction and concessions since 1951. CIR operates in the metallurgical sector, with a history dating back to 1932. The French company Air Liquide is also involved in H24U and describes itself as a global leader in gases and related technologies and services and a pioneer in hydrogen technologies. The collaboration aims to reduce reliance on petroleum-based fuels, especially in heavy cargo transport, and eventually to inject H_2 into the natural gas network in Paysandú. The original project design envisaged two phases. The first phase (scheduled for completion by 2023) assumed the installation of a 2 MW solar farm and 1 gigawatt (GW) electrolyser, and the second phase (until 2024) the conversion of 17 trucks used in the forestry sector to run on GH_2 instead of diesel. The Fund earmarked USD 10 million over 10 years for the H24U project; the total project cost is estimated to be around USD 43.5 million. As of late 2025, the solar PV plants and the electrolysers were still at the pre-construction stage and no forestry trucks had been retrofitted to run on GH_2.

Source: MIEM (Ministerio de Industria, Energía y Minería, 2023)

Furthermore, a Green Hydrogen Sector Fund was established to support the private sector, with an allocation of USD 10 million. This fund was designed to finance R&D, innovation and training projects in the field of GH_2. MIEM, the Technological Laboratory of Uruguay (LATU) and the National Agency for Research and Innovation (ANII) jointly govern the fund. Several companies participated in the first tendering process (Culshaw, 2022). The H24U project emerged as the winner, led by a consortium comprising two Uruguayan companies, Saceem and CIR, and the French company Air Liquide. H24U is considered Uruguay's first green hydrogen pilot project (see Box 1) and a cornerstone of its second energy transition.

The roadmap estimates that green hydrogen production and derivatives could reach nearly 1 Mt per year by 2040 for a range of applications. This level of production would require the installation of 18 GW of renewable energy generation capacity and 9 GW of electrolyser capacity and result in an annual water consumption of 10 million cubic metres, based on the assumption that 9-10 kg of (clean) water is required to produce 1 kg of H_2.

Uruguay plans to use the GH_2 produced in domestic sectors such as transport (heavy-duty vehicles, long-distance passenger services and agricultural vehicles), pulp and paper, shipping

and agriculture. The roadmap indicates that export prospects depend on the country's performance relative to other potential exporting countries and regions such as the Middle East, Brazil, Chile and North Africa. Competitiveness varies depending on the product and destination. Regarding hydrogen, e-methanol,[5] e-Jet Fuel[6] and direct reduced iron,[7] Uruguay's landed costs[8] align with those of its primary competitors. Regarding green ammonia, the roadmap considers the establishment of a domestic fertiliser industry feasible but states that there is still a price gap between green fertiliser and the conventional fertiliser produced using natural gas (MIEM, 2022, p. 37).

Overall, the roadmap presents a very optimistic assessment of the impacts that the green hydrogen economy may have in the country in the short and medium term. One of the key assumptions is that, based on favourable renewable energy potentials (wind and solar), production costs could range between USD 1.20-1.40 per kg by 2030. The potential installed renewable energy capacity is estimated at more than 90 GW (wind 60 GW, solar 30 GW) at sites "with the best wind and solar resources".

These are very ambitious targets, given that, today, after the first phase of its energy transition, Uruguay has around 1.5 GW of installed wind capacity (Dialogue Earth, 2025) and approximately 300 MW of installed PV capacity. With less than 2 GW of installed wind and solar capacity, Uruguay now generates up to 99% (IEA, s.a.-a) (2024) of its electricity from RE (Markert, 2024; MIEM, 2025). A substantial increase in electricity generation would require a coordinated expansion in demand, either from export markets or from large domestic offtakers (e.g. large data centres).

Uruguay is prioritising non-traditional renewable energy sources such as wind and solar. Hydropower is the traditional low-emission energy source of the country. In 2023, hydropower accounted for 27% of the renewable electricity generation, substantially below the share of wind energy (37%) (IEA, s.a.-a). The hydropower plants were mainly built in the 1980s and these plants utilise around 100% of the country's hydropower potential (Casaravilla & Chaer, 2021, p. 4). Thus, no larger-scale hydropower plants will be built in the coming decades. The future of bioenergy is a little less clear; today it accounts for 17% of the electricity mix (IEA, s.a.-b). Uruguay has ambitions to become a world leader in bioenergy innovation (BioEconomía.info, 2024). The extent to which bioenergy will change the electricity mix is still uncertain. It seems likely that instead of biomass combustion, innovative uses of biomass will be promoted, for example modern timber construction. Of particular relevance to this study is the option of using biomass, for example residues from the forestry and timber industries, to produce SAF, for example via the Hydrotreated Esters and Fatty Acids (HEFA) process (SKYNRG, s.a.).

These optimistic projections reflect Uruguay's confidence in its substantial competitive advantages, which could enable it to establish itself as a prominent producer of GH_2 and its derivatives (MIEM, 2022, pp. 23ff.) and as an attractive destination for foreign investment due to political, institutional, legal and macroeconomic stability. Another favourable condition for GH_2 is the availability of freshwater from numerous rivers and access to the Atlantic Ocean. Average annual rainfall is high, at 1,320 millimetres (for context, Argentina recorded a significantly lower annual rainfall of 591 millimetres in 2020; World Bank, 2024b). Having access to the Atlantic Ocean via the Port of Montevideo, Uruguay enjoys shorter shipping routes to Europe and the

5 Meaning methanol that is produced using electricity generated from renewable energy sources.

6 Meaning a synthetic liquid fuel that is produced using electricity generated from renewable energy sources.

7 Direct reduced iron is a steel production method utilising iron ore and hydrogen instead of coking coal as a reduction agent. If successfully implemented, this process contributes to the demand for hydrogen in a country (IEA, 2019, p. 108).

8 Meaning the total costs of a product upon reaching the buyer's destination, covering production, transport, insurance and additional costs.

United States than other potential hydrogen exporters, such as Chile. Furthermore, the country has well-established river and road transport systems and has plans for a central railway connecting the areas with the greatest renewable energy generation potential to the Port of Montevideo (MIEM, 2022, p. 9).

The roadmap outlines both benefits and risks associated with the development of the hydrogen sector. Thirteen primary risks have been identified and categorised into four groups. Furthermore, mitigation strategies have been developed specifically for the six risks deemed to have the greatest likelihood of occurrence and the most impact at the national level (MIEM, 2022, pp. 48ff.).

Uruguay has completed the first phase (2022-2025) of the roadmap, which focused on developing a regulatory framework, launching initial pilot projects and attracting the first export-scale projects. The second phase (2026-2030) provides for the expansion of the domestic hydrogen market and the launch of the first export projects. For the third phase (starting in 2030), the roadmap envisages developing a large-scale domestic market and accelerating export growth.

2.3 Hydrogen projects in Argentina and Uruguay

The following tables provide an overview of projects related to the production of LEH_2 in Argentina and Uruguay, as of the end of 2025. The list includes projects at different stages of development and is based on IEA data, supplemented by further data sources (including policy documents and media reports) and information gathered during the interviews. It is important to note that most projects are currently at the pre-FID stage (before a final investment decision), which may involve steps such as leasing or purchasing land and conducting environmental and social impact assessments (ESIAs) before making a decision to proceed. It is uncertain whether these projects will reach FID and ultimately be implemented. Argentina has two pilot projects: one is operating (see Hychico) and the other is undergoing maintenance (Pico Truncado).

Table 2: Hydrogen-related projects in Argentina

Project name	Location	Partners	Planned start of operation	Status (as of October 2025)	Type of energy	Goal
Hychico	Comodoro Rivadavia, Chubut	Capex S.a. (Argentina), Enercon (Germany), Jenbacher (Austria)	2008	pilot plant	onshore wind	Combine H_2 and gas used to power a 1.4 MW motor
Pico Truncado	Pilot training plant	Santa Cruz Province	2006	operative (under maintenance)	onshore wind	GH_2; gas blending and O_2
Pampas Project (Fortescue)	Large project	Rio Negro and other Provinces in Patagonia	n/d	pre-FID	onshore wind	GH_2, other green derivatives and port infrastructure
ENARSA and Fraunhofer Institute	Bahía Blanca	ENARSA, FhG	n/d	announced (MoU signed)	offshore wind	n/d
MMEX Resources Corporation	Tierra del Fuego	MMEX Resources Corp (USA), Siemens (Germany)	2027	announced	onshore wind (160 MW)	ammonia and methanol
Profertil	Bahía Blanca	YPF (Argentina), Nutrien (Canada), Adecoagro (Luxembourg)	2027	pre-FID	onshore wind (300 MW)	ammonia
ORKEKE	Santa Cruz Province	Acciona Energía (Spain), Nordex Group (Germany)	2027	pre-FID	onshore wind (2.6 GW)	ammonia for export
ABO	Patagonia	ABO Energy (Germany)	n/d	announced	onshore wind	NH_3
RP GLOBAL	Santa Cruz and Rio Negro	RP Global (Austria), GIZ (Germany)	n/d	pre-FID + GIZ financial support	onshore wind (3 GW)	GH_2
HDF Energy	Tierra del Fuego	HDF Energy (Hydrogène de France)	n/d	n/d	onshore wind	GH_2 for mining and isolated areas
CWP Global	Golfo San Jorge, Santa Cruz and Tierra del Fuego	CWP Global (Serbia)	n/d	pre-FID	onshore wind	GH_2, ammonia
Green Capital	Patagonia	Green Capital S.A. (Argentina)	n/d	announced	onshore wind	ammonia
POSCO	Patagonia	Posco (South Korea)	n/d	announced (MoU)	onshore wind	GH_2 and ammonia
Eco-Refinerías del Sur (Eco-Refineries of the South)	Chubut	Green Sinergy (Germany), Axens (France), Eco Refinerías del Sur (ARG)	2030	announced (MoU)	onshore wind	SAF

Source: Authors

Table 3: Hydrogen-related projects in Uruguay

Project name	Location	Partners	Planned start of operation	Status (as of October 2025)	Type of energy	Goal
H24U Project	Pueblo Centenario (Durazno Department)	SACEEM (Engineering) / CIR (energy and technology), both Uruguayan companies	2025 or 2026	Preparatory work started	solar PV	Decarbonising heavy cargo transport, especially in the forestry sector, using hydrogen-powered trucks
Kahirós	Fray Bentos (Río Negro)	Ventus, Fraylog Hyundai-Fidocar, Montes del Plata (offtaker)	second half of 2026	Fully active construction phase	solar PV	Promote the use of RE within the forestry logistics sector
Tambor Green Hydrogen Hub Enertrag	Tambores Departamentos de Paysandú y Tacuarembó	Bellasay S.A., Joint Venture of Enertrag (Germany) and SEG Ingeniería (Uruguay)	2027-2028	First environmental authorisation request in Dec. 2024; 2025: awaiting final environ-mental approval before construction may begin	wind and solar	E-methanol from H_2 and biogenic CO_2
Paysandú Green Hydrogen	Paysandú	HIF (Chile / Peru / USA), Porsche, Siemens, ALUR as partner	n/d	Revised planning after the ESIA study; scaled-down design submitted	wind	E-methanol and e-gasoline from GH_2 and biogenic CO_2
H2U Offshore	Offshore blocks along Uruguay's South Atlantic coast	ANCAP	n/d	concept and consultation	offshore wind	To develop GH_2 and its derivatives for export (e-methanol and e-ammonia) using offshore wind power
Alfanar	Rocha Department	Alfanar Energía (Saudi Arabia) Alfanar Energía España	n/d	announced	wind and solar	GH_2, ammonia

Source: Authors

3 Research focus, research design and stakeholders surveyed

By their nature, new technologies reconfigure the risk landscape for firms, policymakers and society at large. Clean hydrogen is no exception: Its complex value chain, spanning production of H_2 and its derivatives, their distribution and transport, and their use in energy-intensive industries, magnifies the uncertainties associated with new technical systems. Therefore, the primary research question underlying this study is the following: *How do the main actors and stakeholders in the hydrogen economy perceive the uncertainties involved, and which policies and modes of international cooperation contribute to mitigating them?*

To answer this question, we broke it down into three subquestions:

1. Which value chain opportunities do actors perceive, and how do these shape their engagement with the hydrogen economy?

2. Which challenges and uncertainties do actors consider most critical, and how do these vary across stakeholder groups and geographical contexts?

3. How do actors assess the effectiveness of state intervention and international cooperation in reducing these uncertainties?

The first subquestion is important, as perceptions of uncertainty depend on perceived opportunities: Actors who perceive substantial opportunities tolerate more uncertainty. Responses provide a basis for addressing the main research question, as they make uncertainty assessments comparable and interpretable.

Argentina and Uruguay were selected as case studies because, in recent years, both countries had shown a clear interest in developing a hydrogen economy and adopted hydrogen strategies in 2022 (Uruguay) and 2023 (Argentina). They also consider exports of H_2, derivatives (ammonia, methanol) and related products (e.g. direct reduced iron, SAF) to be an important strategic pillar of their hydrogen strategies. There is also considerable scope for international cooperation: Germany as a potentially important partner (e.g. as a technology provider and an import market) has formalised a hydrogen partnership with Uruguay (Joint Declaration in 2023) and included Argentina in the International Hydrogen Ramp-up Programme (H2Uppp).

A particular “black box” in the development of an international hydrogen economy is the process of policy implementation. This was the starting point for the research project in Argentina and Uruguay. From the first exploratory conversations, it became clear that policymaking in both countries cannot be conceptualised exclusively as a rational response to external stimuli, taking into account national capabilities and long-term goals. First, the political economy comes into play. Various stakeholder groups with differing or even completely opposing interests influence policymaking directly and indirectly. In addition, the external conditions for establishing a hydrogen economy remain uncertain and in flux, including when an international hydrogen market will be established, how large it will be and what prices offtakers might be willing to pay.

3.1 Research design and methodology

To gain insights into the uncertainties influencing stakeholder decision-making in Argentina and Uruguay in the context of a low-emission hydrogen economy, an extensive empirical study was carried out. The study was jointly designed and conducted with partner universities in Argentina (Universidad Nacional de Quilmes and Universidad Nacional de General San Martín) and Uruguay (Universidad de la República) as part of the IDOS Postgraduate Programme. In total,

the research team comprised four senior researchers from Argentina and Germany and six postgraduates (three from Germany, two from Argentina and one from Uruguay).

After a preparatory phase of three months (11/2023-01/2024), in which stakeholder maps for both countries and the research design were jointly developed, an empirical phase of equal length (02/2024-04/2024) followed, during which the research team conducted semi-structured expert interviews and focus group discussions in both countries. Interview guidelines, adapted to the different stakeholder groups, focused on opportunities, challenges and the role of policy and international cooperation in the current low-emission hydrogen market (see Appendix). With regard to uncertainties, the interviews began with a discussion of challenges and progressively encouraged participants to link these challenges to the topic of uncertainty. This allowed us to circumvent the common challenge associated with questions about uncertainty and thereby obtain “natural” responses without prompting interviewees to adopt predefined concepts of uncertainty (see e.g. Sun, 2021).

In total, 75 interviews were conducted in the capital cities and in regions with planned hydrogen projects, and one focus group discussion was organised with civil society actors at the site of a contested green hydrogen project in Uruguay (see next section). Each of these activities involved the participation of team members from at least two countries. At the end of the research period, the preliminary findings were presented to stakeholders in both countries during hybrid workshops to receive feedback.

During the exploratory research, the team created a directory of relevant codes for types of uncertainty based on academic and grey literature and used it to analyse the interview transcripts. The extraction and evaluation of the material broadly followed the guidelines developed by Gläser and Laudel (2010), who developed a flexible and evolving framework for conducting qualitative research based on expert interviews, which allows including analytical dimensions that emerge during the empirical phase but that were not considered in advance. In addition, we distinguished between uncertainties that can potentially be managed by domestic stakeholders or through national control mechanisms (e.g. markets, regulations) and those that require international cooperation or multilateral intervention (external uncertainties).

All team members were involved in the process to ensure a country-neutral perspective and a shared understanding of the findings.

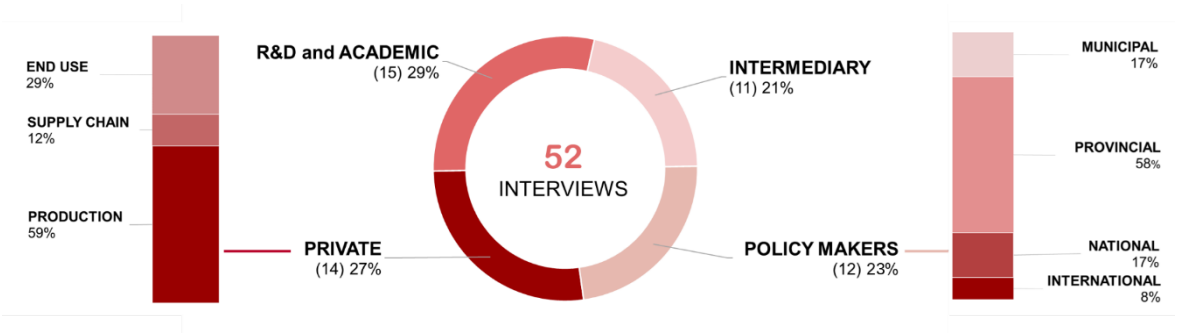
3.2 Stakeholders interviewed

We endeavoured to involve as wide a range of stakeholders as possible in both countries. The interviewees were assured of anonymity. The following two sections provide an overview of the stakeholders interviewed within the time available.

3.2.1 Stakeholders interviewed in Argentina

To gain as broad a perspective as possible on the potential of the low-emission hydrogen economy and related challenges in Argentina, face-to-face interviews were carried out with 52 stakeholders. Other stakeholders were contacted but were not included in the sample, either because it was not possible to arrange a meeting during the project period or because they did not agree to an interview. It should be considered that the research was conducted during a period in which Argentina was experiencing a major change in government involving substantial shifts in economic, energy and environmental policy. In addition, many private-sector stakeholders were hesitant to express their positions. Many of them, however, were represented by associations or chambers of commerce whose representatives were interviewed, providing indirect insights into the development of the project.

Figure 1: Overview of stakeholders interviewed by sector (Argentina)



Source: Authors

As shown in Figure 1, interviewed stakeholders came from the public sector; the research and technology ecosystem; private-sector companies; and intermediaries linking stakeholders in the emerging hydrogen economy. Policymaker interviewees included representatives of national, provincial and municipal governments, as well as foreign embassies in Argentina. Within the private sector, most of the stakeholders who contributed to the research were involved in the production stage of the low-carbon hydrogen economy. These included companies involved in supplying energy and material inputs, processing and hydrogen production; together, these companies accounted for almost 60% of the interviews with private-sector stakeholders. In the end-use sector, companies were contacted primarily in logistics, fertiliser production and other energy-intensive industries. Given the early stage at which the hydrogen economy currently finds itself, research, technology and academic institutions play an important role in the low-carbon hydrogen sector. Representatives of 15 institutions in this group were interviewed as part of the project, including several higher education and federal public research institutions and public offices at both the national and provincial levels.

Most of the interviews were conducted in the Buenos Aires Metropolitan Area, which refers to the urban agglomeration comprising the Autonomous City of Buenos Aires and the adjacent districts in the Province of Buenos Aires. Almost 60% of all interviews conducted took place in the Buenos Aires Metropolitan Area. These interviews included stakeholders operating in the region; those with representation throughout the country but based primarily in Buenos Aires; and stakeholders with interests in other provinces but corporate offices in the Buenos Aires Metropolitan Area.

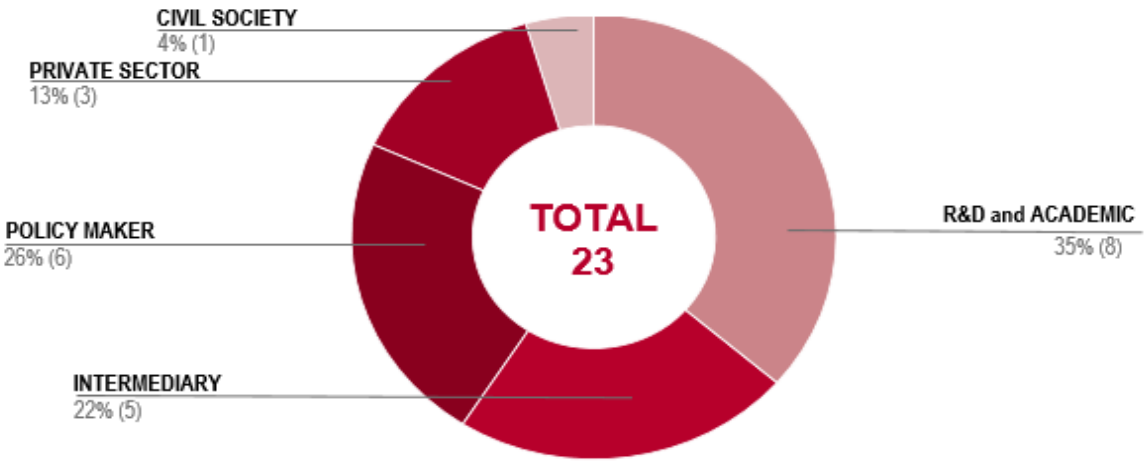
In addition to these interviews, the research team travelled to several provinces where hydrogen-related projects were being developed. In the Province of Chubut,[9] nine stakeholders linked to the hydrogen sector were interviewed, in Comodoro Rivadavia and Puerto Madryn. In Tierra del Fuego, the research team conducted six interviews in the cities of Ushuaia and Río Grande. The city of Bahía Blanca is located in the south of the Buenos Aires Province and is an important energy and petrochemical hub, with strong potential for wind power generation. In the Bahía Blanca area, eight interviews were conducted with representatives of the public sector, research institutions, hydrogen production projects and potential industrial and transport-sector offtakers. Finally, representatives of one company with interests in the hydrogen supply chain sector were interviewed in the Province of Mendoza.

9 The Chubut Province in Argentina's south has favourable conditions for renewable energy generation. Wind farms currently operating in the province have load factors among the highest in the world.

3.2.2 Stakeholders interviewed in Uruguay

In Uruguay, 23 interviews were conducted with stakeholders directly or indirectly involved in the green hydrogen economy. Most of the interviews were conducted in the city of Montevideo, the political and economic capital of the country that hosts almost half of the population. In addition, a workshop was held in Tambores (Department of Tacuarembó, northeastern Uruguay), where the Tambores project to produce GH_2 and derivatives is planned, led by Belasay S.A. This company was formed through a partnership between the German company Enertrag and the Uruguayan company SEG Ingeniería; it was established for the legal purpose of presenting the Ministry of Environment (late 2021) with the request to operate in Uruguay (Méndez, 2023). Representatives of both companies were interviewed as part of this research.

Figure 2: Overview of stakeholders interviewed by sector (Uruguay)



Source: Authors

Three public companies linked to the development of the energy and hydrogen sectors were included in the sample. Academic-sector interviewees included researchers from various disciplines at the Universidad de la República, including chemistry, engineering, hydrogeology, social sciences and development studies. Representatives of the "Academic Hydrogen Network for the Promotion, Research and Development of Hydrogen and Decarbonisation in Uruguay" (REDH2UY) were also interviewed. This is a multidisciplinary network made up of researchers from the Universidad de la República, the Technological University of Uruguay and the Clemente Estable Biological Research Institute (IIBCE). The network was established to coordinate and promote research on H_2 and decarbonisation in Uruguay, support new studies, communicate the findings to the public and train professionals in the field.

Within the private sector, representatives of the country's main green hydrogen production companies, consultants and representatives of specialised certification companies were interviewed. National representatives with extensive experience in the country's energy transition and the hydrogen economy were consulted. In addition, a public official from the Department of Tacuarembó was interviewed and provided a valuable local perspective on the process.

Uruguay's small size and population mean that many of the stakeholders involved in developing GH_2 fulfil multiple roles across the public sector, academia, sectoral representation and policy-making. The existence of a cross-sectoral collaboration network and the resulting synergies were mentioned as a distinct competitive advantage for Uruguay over other countries in the region.

4 Analysing framework conditions, uncertainties, stakeholders' interests and hydrogen policymaking

4.1 Argentina

The following section summarises the main findings from the interviews we conducted in Argentina. Given the wide array of stakeholders and the fact that the topic is still developing, there was no consensus among the stakeholders in Argentina on the issues discussed. Wherever possible, we present both majority views and divergent minority opinions.

4.1.1 Techno-economic framework conditions and H_2 production routes

Argentina possesses a range of advantages that position it as a promising producer of LEH_2 (including green, blue and pink hydrogen) for both global and domestic markets. In terms of natural resources for green hydrogen production, the country has some of the world's highest levels of solar irradiation, particularly in the Cuyo region and the north-west. Moreover, in the central and north-eastern regions, there is potential to use dry and wet biomass. Additionally, Patagonia benefits from wind power capacity factors exceeding 60% in some areas, among the highest globally. Furthermore, for blue hydrogen production, Argentina has Vaca Muerta, the second-largest shale gas deposit in the world, where the geological conditions are also favourable for carbon capture, utilisation and storage (CCUS). The country has a decades-long tradition of developing nuclear energy capabilities. It follows logically, therefore, that Argentine stakeholders were considering the possibility of producing electrolytic hydrogen using nuclear energy from existing or new nuclear power plants (PH_2). As early as 1950, the National Atomic Energy Commission (Comisión Nacional de Energía Atómica) was established, and the first commercial nuclear reactor went online in 1974. More recently, the country made significant advancements in developing small modular nuclear reactors. Another geographical advantage for Argentina is its extensive coastline, which provides significant access to seawater that would need to be desalinated for hydrogen production. Additionally, this coastline offers various options for developing export ports, in addition to the existing port of Bahía Blanca. Interviewees highlighted these strengths of the country.

The interviews indicated that nearly half of the stakeholders believed Argentina should focus on the production of GH_2, while more than a third believed that Argentina should pursue both green and blue hydrogen production, with BH_2 serving as a transitional step towards GH_2. A small number of stakeholders proposed a "rainbow" approach to production that encompasses green, blue and pink hydrogen. These findings suggest that, given Argentina's diverse resources and capabilities, there was no unanimous view on which production route the country should follow. There was also no consensus on whether BH_2 should complement GH_2 or serve as a preliminary step towards it.

It is important to highlight that those who advocated BH_2 as a complement to GH_2 or as a preliminary step towards it were often industry stakeholders and, in some cases, linked to the oil and gas sector. Many of them also argued that Argentina should leverage its gas resources. This view was often expressed by stakeholders residing in regions with hydrocarbon production. In contrast, those who believed Argentina should focus on green hydrogen production from the outset were more closely associated with the renewable energy sector. In the end, those who also highlighted the possibility of producing PH_2 were, for the most part, individuals linked to the nuclear sector. A substantial proportion of interviewees considered access to a port, as in Bahía Blanca, a regional advantage. By contrast, in Tierra del Fuego, particularly Río Grande, the lack of a port that could support hydrogen production and exports was seen as a regional disadvantage.

Even those who favoured the hydrogen economy regarded limitations in the country's electricity grid infrastructure as a major obstacle. These challenges stem from the limited transmission and distribution infrastructure in key production areas. This raises the question of whether hydrogen projects should be connected to the grid. Many interviewees believed that larger projects should operate independently, while medium-sized projects should be integrated into the existing grid.

There was a strong consensus that export markets would be more important for H_2 than Argentina's domestic market. Large-scale H_2 exports could lead to technology transfer from abroad, support domestic learning and reduce the costs of components – things that could not be achieved within the domestic market, which was still considered to be too small. Many stakeholders believed that Argentina would first become a significant player in the global market for liquefied natural gas and later might establish a position in the low-emission hydrogen market. Europe and Asian countries were identified as the most important potential export destinations, with Asian markets seen as potential destinations for BH_2 and its derivatives. Some stakeholders believed that exports should be accompanied by developments in the domestic market to support learning for larger-scale projects.

Most interviewees saw the demand in international markets as the main driver of hydrogen-related activities in Argentina, followed by the anticipated effects of a domestic carbon market.[10] Most interviewees believed that external trade would focus on ammonia and/or methanol.

4.1.2 Opportunities for local value creation and for the domestic market

Producing H_2 is complex and goes far beyond installing an electrolyser. Rather, it requires capital goods for renewable energy generation, complex services, plant design, digital controls, equipment and systems for transporting and storing H_2 and its derivatives. These requirements could create a range of opportunities for value creation in producing countries, including Argentina and Uruguay. The specific opportunities that arise depend largely on each country's existing industrial and technological capabilities and how the market ramp-up is shaped by policy.

We asked our interviewees a series of questions to ascertain what opportunities domestic hydrogen use could create for local value creation, how they would assess the challenges of decarbonisation and the country's potential to generate a local supplier base and create opportunities beyond those arising from its natural resource advantages.

A large majority of interviewees rated highly Argentina's industrial, scientific and technological capabilities. However, there were different perspectives on how and when these capabilities could generate opportunities for local value creation in the hydrogen value chain. Most stakeholders assumed that local suppliers would not be able to provide equipment and sophisticated services directly related to electrolysis, the core technology in green hydrogen production. They attributed this mainly to project timelines and anticipated project scales. Such opportunities might arise in the longer term, and in smaller-scale projects, including pilot projects. From this perspective, many elements required along the hydrogen value chain would have to be imported.

A smaller group of stakeholders believed that Argentina had established capabilities in the gas value chain and petrochemical industry. They considered adaptation to hydrogen-related requirements relatively straightforward, suggesting that local suppliers could support the development of the hydrogen economy in Argentina in the shorter term. Specifically, the identified potential areas for value creation were:

10 Argentina is exploring an Emissions Trading System as part of its National Strategy for the Use of Carbon Markets (Estrategia Nacional para el Uso de los Mercados de Carbono, ENUMeC), approved in 2023.

- Management and maintenance of wind farms;
- Management of geological storage sites for hydrogen and for CCUS;
- Development of electrolyser components and/or electrolysers for niche markets involving smaller-scale projects (e.g. refuelling stations and mining applications);
- CO_2 management: creation of a new CCUS value chain as an opportunity arising from BH_2 production;
- Development of vessels, equipment, valves and pipelines;
- Contribution to SMR for BH_2.

An example of technological development mentioned by some interviewees as a step towards capturing value creation opportunities was the prototype electrolyser project led by Y-TEC.[11] The purpose of this project was to enable Argentina to produce GH_2 using domestic technology, reduce dependence on imports and support the country's energy transition. The project was announced in 2022 as part of Argentina's NHS. In 2024, the equipment was built and assembled at Y-TEC's facility in Berisso, in the Province of Buenos Aires.

There was a strong consensus among interviewees that starting with pilot projects was important to gain a deeper understanding of the technologies, reduce production risks and develop both workforce skills and a local supplier base in the hydrogen value chain.

Domestic market

The incentives to use H_2 to decarbonise domestic industrial processes or transport are weak. For instance, at the time of the interviews, Argentina did not yet have a stable carbon pricing mechanism or Emissions Trading System in place. The local market is limited by the availability and cost competitiveness of alternative energy sources, such as gas.[12] Therefore, most stakeholders considered that the domestic market would remain marginal, with some expecting hydrogen production to serve export markets exclusively in the future. Another group believed that, despite its small size, the domestic market was important to support the learning needed to ramp up to larger projects, serve international markets and create local added value.

In this context, potential hydrogen applications were envisaged on a small scale. The main applications mentioned by the interviewees were synthetic fuels (bunkering) as a niche market for shipping, including tourist cruise ships and other vessels that dock in Patagonia, particularly Ushuaia (Tierra del Fuego) and Puerto Madryn, two destinations attracting international tourists. Other niche applications mentioned included hydrogen use in mining transport and as a feedstock in the steel sector (direct reduced iron).

In general, LEH_2 can be used to produce ammonia, which is the basis for nitrogen fertiliser. The Haber-Bosch process, which is the core technology for ammonia production, can use emissions-intensive hydrogen from SMR, LEH_2 or a mixture of both. Most interviewees were sceptical about the possibilities of using H_2 as a feedstock for NH_3 production. Given the much higher

11 Y-TEC was founded in 2012 as a joint venture between YPF (Argentina's main oil company, with both public and private ownership) and the National Scientific and Technical Research Council (Consejo Nacional de Investigaciones Científicas y Técnicas, CONICET).

12 It should be emphasised that the interviews were conducted and evaluated at a time when Argentina's Emissions Trading System was not yet operational. Further research should assess whether implementing the scheme would increase the willingness of emissions-intensive industries to transition to cleaner energy carriers, such as hydrogen.

production costs of green ammonia compared with conventional ammonia produced through SMR, interviewees feared that a transition would increase food prices, which would have significant implications for the economies of the region. Other interviewees, however, identified the fertiliser sector as an opportunity once a carbon market was established. Green ammonia could also offer export opportunities.

Box 2: Industrial development and the scientific and technological system in Argentina

Argentina has more than 50 years of experience in the petrochemical industry and oil refining. Consequently, this extensive experience has helped build a robust network of suppliers and a skilled workforce with expertise relevant to the hydrogen value chain and capital goods production. Additionally, Argentina has one of the leading scientific and technological systems in Latin America, with substantial experience in H_2. More than 50,000 researchers work in the National Science and Technology System. Most researchers are located in I&D (innovation and development) groups at national universities and in the National Scientific and Technical Research Council (CONICET). Other decentralised institutions, such as the National Atomic Energy Commission and the National Institute of Industrial Technology (INTI), also conduct applied research relevant to the hydrogen economy. Notably, each year, the country produces more than 17,000 graduates in applied sciences and more than 3,500 in various engineering disciplines (SSA, 2023, p. 14).

In 2022, Y-TEC began developing an alkaline electrolyser in close cooperation with CONICET, based on local knowledge and manufacturing skills. More than 30 researchers and technicians were included in the project. By mid-2023, Y-TEC had developed a laboratory-scale prototype capable of producing 0.5 Nm^3/h (normal cubic metres per hour) of H_2. The plan was to scale up the project and build a 1.2 MW electrolyser capable of producing 200 Nm^3 of hydrogen per hour. The electrolyser was intended to be integrated into a steel plant belonging to the Techint group (Siderca, Province of Buenos Aires), which mainly produces pipes and tubes for the hydrocarbon industry. However, following the change of government and changes in the management of YPF (which controls Y-TEC), the project lost momentum and Techint-Siderca also seems to have lost some interest in the technology.

4.1.3 Environmental and social issues

Social and environmental commitments are part of the normative basis of the emerging hydrogen economy to achieve a fair and sustainable energy transition. The research team therefore included an analysis of the risks and/or challenges involved in meeting international social and environmental commitments across different regions of the country. The findings varied across the areas where projects were planned and/or actors were located, reflecting the geographical and cultural contexts of the populations near potential hydrogen production hubs.

In general, a large majority of stakeholders living and working farther from planned project sites believed that *environmental aspects* needed to be addressed but were not among the main challenges in Argentina and could be resolved if managed well. In this context, stakeholders located in areas with planned hydrogen projects and closer to the communities emphasised the importance of working with the local populations beforehand, raising awareness and involving people to secure a social licence[13] to operate. In several provinces of Patagonia, there had been cases in which large-scale projects (in sectors other than H_2) had been stopped by project developers due to insufficient or inadequate engagement with local communities and other stakeholders. As an example, interviewees mentioned the initiatives to introduce salmon farming

13 A “social licence” refers to the informal approval or acceptance granted by a community or stakeholders for a company or project to operate beyond formal legal or regulatory permissions.

in Tierra del Fuego, which were prohibited by law due to environmental concerns (ecosystem degradation, the spread of disease and pollution of pristine waters). The ban imposed in 2021 remained in place at the time of writing, and interviewees attributed this to a lack of community engagement by the companies concerned, which prevented them from securing a social licence from the local populations.

Environmental concerns are relevant throughout Patagonia but vary in prominence within and between provinces depending on the specific issue. Key issues include:

- access to water and its responsible management and use,
- potential competition and/or synergies with other economic activities in the territory or communities,
- preservation of landscapes, natural reserves and cultural heritage.

In Chubut, the city of Puerto Madryn has a biologically rich but fragile marine environment. The region's tourism economy depends heavily on whale watching and pristine coasts. Environmental concerns are very important to the community, and many people do not consider it to be a viable area for hydrogen projects. In contrast, Comodoro Rivadavia and its surroundings, which also belong to Chubut, appear to face fewer environmental tensions in these aspects, partly because Comodoro Rivadavia has developed around a strong oil and gas industry since the early 20th century, including the presence of foreign hydrocarbon companies.

Significant land-use conflicts were identified in other areas where tourism is important. For instance, the capital of Tierra del Fuego, Ushuaia, attracts large numbers of domestic and international tourists. Among its other roles, Ushuaia is an important starting point for Antarctic expeditions. Some interviewees also saw competition between hydrogen-related activities and traditional land uses, such as livestock farming, which generates income for the local population.

Despite having large rivers and aquifers, some regions of Argentina – especially in Patagonia and arid northern provinces – face seasonal or chronic water shortages. This challenge could worsen as climate change leads to higher rainfall variability and an acceleration of glacier retreat in the Andes. Thus, seawater desalination may need to be considered to enable commercial-scale hydrogen production. A large majority of stakeholders interviewed mentioned the need to resolve issues related to seawater desalination and improve the efficiency of the plants. The main concern raised about brine was its high salinity and chemical content, which can harm marine ecosystems when discharged improperly.

With regard to *social aspects* of a hydrogen economy, interviewees focused on potential employment effects and related workforce training needs. Many emphasised that alongside permanent jobs directly linked to the value chain (e.g. operation of wind and solar farms and electrolysers) additional – and potentially more numerous – jobs might be created in the initial phase, for example when renewable energy facilities are established to feed electrolysers. It was also mentioned that in secondary or ancillary activities (maintenance, replacement of wear parts such as electrodes, membranes and seals) job creation could be substantial.

Respondents emphasised the need to provide adequate training to a sufficient number of people in the relevant age groups in order to realise the desired employment benefits. The starting points for this challenge vary significantly across the country. For instance, Bahía Blanca (in the south of Buenos Aires Province) has extensive capacity to deliver short-term education and training with a comparatively large population. In this sense, some interviewees suggested that for certain regions (e.g. in parts of Patagonia) with lower population densities, incentives should be strengthened to attract workers and equip them with the skills needed for future hydrogen-related activities.

Box 3: Main features of Argentina's provinces regarding energy and industrial projects

Each province in Argentina offers distinct advantages and challenges for industrial, energy and hydrogen development, ranging from natural resources and infrastructure to socio-political dynamics. Understanding these factors is crucial for strategic decisions about the possible establishment and expansion of hydrogen production facilities in the respective regions.

Buenos Aires Province

This province has two main potential hydrogen hubs: the area surrounding the capital, Buenos Aires, and the petrochemical hub in Bahía Blanca. Bahía Blanca benefits from the best wind conditions in this province, robust port infrastructure, ample land and access to seawater from the Atlantic Ocean. However, using seawater requires desalination, thus increasing both capital and operating costs. Currently, no desalination plants are planned in the province. The city's extensive industrial activities, centred on a major petrochemical complex, make it a key hub for Argentina's domestic and international chemical production activities. The port of Bahía Blanca is well positioned for hydrogen derivative exports and could therefore be a suitable location for Argentina's first hydrogen pilot project. Despite these advantages, residents have raised significant environmental and health concerns about the industrial activities in and around Bahía Blanca.

Chubut Province

Chubut has sufficient land suitable for a range of industries and has expertise in the oil and gas sector. Freshwater scarcity and political divisions arising from differing objectives between the northern and southern regions of the province could present challenges. In the north of the province lies the city of Puerto Madryn, renowned for its pristine coastal wildlife sanctuary, home to sea lions, whales, penguins and a diverse array of bird species. Environmental protection and biodiversity conservation are paramount for the majority of residents here. They staunchly oppose mining activities, prioritising environmental conservation above all else. In this context, only green hydrogen production would be tolerated. The southern part of the province, close to Comodoro Rivadavia, has experience in the oil and gas sectors and favours technological advancement. Stakeholders here were open to blue hydrogen production.

Tierra del Fuego Province

In Tierra del Fuego, the availability of land for wind farms, access to saltwater and tax incentives make the region attractive for investment from other provinces and abroad. However, limited transport connectivity within the province and with other regions poses significant obstacles.

Residents of Ushuaia, a tourism hub, have a strong environmental consciousness and want to be involved in decision-making processes for new technologies and projects, including H_2. Due to the mountainous coastal terrain, Ushuaia is unsuitable for onshore wind farms. By contrast, the industrial city of Río Grande, with its flatter terrain and greater land availability, is better suited for the creation of wind farms. Yet, variable wind conditions and the absence of a port in Río Grande present notable challenges.

4.1.4 Political, regulatory and institutional aspects

Many interviewees identified Argentina's *political instability* as a major concern. The country's political landscape often swings dramatically, leading to uncertainty and substantial changes in regulations. Additionally, some stakeholders acknowledged that political decisions would influence which types of H_2 (green, blue and/or pink) would be prioritised for development. Consequently, frequent changes of government and shifts in political ideology hinder the

establishment of a consistent strategy. Stakeholders therefore stressed the need for clear policy direction to enable private companies to align their strategies. Representatives of Argentina's industrial sector emphasised the importance of balancing the promotion of large investments with the implementation of regulations that support the development of local industrial supply chains.

Another major challenge highlighted in the interviews was Argentina's *macroeconomic situation*, characterised by high inflation, high interest rates and a volatile currency market. These economic conditions create major hurdles to developing a hydrogen economy, particularly in importing equipment and obtaining foreign currency for payments and transactions. Such instability discourages foreign investment, which is crucial for the scale of investment required for green hydrogen projects. Stakeholders agreed that macroeconomic instability increased the cost of financing, making it more difficult to secure the necessary funds.

To encourage capital-intensive investment, Argentina needs a framework to promote investment and provide legal certainty. To this end, bills have been presented in Congress aimed at providing a framework of fiscal and regulatory stability for the development of the hydrogen economy. Additionally, some of these bills aim to foster the diversification of Argentina's industrial and technological base.

Another important aspect regarding the institutional framework is the need to harmonise domestic policies with international standards. Many interviewees highlighted the lack of such harmonisation as a challenge. International standards, especially European ones, are particularly relevant and sometimes difficult to meet when the envisaged project is export-oriented and grid-connected.

Box 4: Towards a regional certification scheme for low-emission hydrogen: CertHiLAC

Argentina, Uruguay and other Latin American and Caribbean countries have laid the groundwork for establishing a regional certification scheme for GH_2: Certification System for Clean and/or Low-Carbon Hydrogen and its Derivatives in Latin America and the Caribbean. A comparable European initiative is the CertifHy regional certification scheme. The Inter-American Development Bank (IDB) has spearheaded these efforts, promoting a governance structure led by the Latin American Energy Organisation (OLADE), a supranational institution with regional recognition. During the eighth Energy Week, held in Montevideo, Uruguay, in November 2023, 10 countries in the region signed the Joint Declaration for the Implementation of the Clean and/or Low-Carbon Hydrogen and Its Derivatives Certification System in Latin America and the Caribbean "CertHiLAC". This inaugural regional agreement proposes a comprehensive sustainability framework tailored to the region's specific characteristics. It places particularly emphasis on respecting the decisions of Indigenous communities and water source preservation, while leveraging each country's capacity to execute the necessary measures to ensure its functionality.

For instance, over a 14-year period, the EU approved three renewable energy directives (RED I in 2009, RED II in 2018 and RED III in 2023, the last amending RED II). They contain increasingly ambitious targets for the overall share of RE in the EU's gross final energy consumption and sector-specific sub-targets, including those for transport (in RED III). RED II introduced the concept of renewable fuels of non-biological origin (RFNBOs), such as GH_2. The RED framework establishes standards and verification criteria for maximum GHG emissions and other sustainability criteria in RE, alongside separate requirements for RFNBOs (RED III). Special attention is given to biomass use for the production of RE and RFNBOs, including GH_2. RED III in general permits this pathway, but only under very stringent sustainability criteria. For

instance, biomass for LEH_2 should not come from areas with high biodiversity or high carbon stocks (e.g. primary forests, wetlands).

Most interviewees considered these regulations to be of limited relevance for Argentina, even where exports to Europe were envisaged. The main reason was that most planned projects in the country foresaw off-grid hydrogen production, which they believed could more readily meet international certification requirements, for example by guaranteeing that all electricity used for electrolysis would come from dedicated renewable energy facilities in the project area. They expected this to be much more difficult in the case of grid-connected hydrogen projects. In Argentina, only 46% of the electricity is produced using low-carbon energy sources (including renewables and nuclear), with the remainder generated from fossil fuels, mainly natural gas (LowCarbonPower, s.a.). Producing certified low-emission hydrogen from grid electricity would require complex verification procedures, if it were even possible at all.

Another challenge identified by many interviewees concerning the investment framework in Argentina, including for H_2, was the need to simplify the tax system. As a federal country, Argentina has taxes levied by different levels of government. One proposal put forward by some interviewees was to emulate Uruguay's single-window scheme for investments.

Finally, a significant proportion of interviewees argued that hydrogen-sector legislation should not mandate minimum local content requirements. According to several stakeholders (particularly private-sector chambers of commerce and politicians), current local content requirements were too high and would act as barriers to investment. Some interviewees suggested that local content requirements should initially be set at a low level, with gradual increases over time.

4.2 Uruguay

Compared to Argentina, Uruguay is less varied in its natural resources and geography. For instance, BH_2 is not an obvious option because of a lack of natural gas reserves and neither is PH_2, as the country has no experience in the nuclear energy industry. Likewise, society is less heterogeneous and more consensus-oriented. Especially in the field of energy policy, the main reforms of recent decades were based on broad political consensus. A 2008 multi-party agreement established Uruguay's long-term national energy strategy. This pact set the guidelines for energy development from 2005 to 2030, including ambitious renewable energy targets.

4.2.1 Techno-economic framework conditions and hydrogen production routes

Many international observers consider Uruguay to have competitive advantages for producing GH_2. They arise from both natural conditions and man-made locational advantages.[14] Green hydrogen projects may benefit from freshwater sources, abundant sunshine and favourable wind conditions. As wind speed in Uruguay usually peaks in the late afternoon and the evening while solar PV output peaks during the day, the combination of wind and solar energy may allow electrolysers to operate for many full-load hours (FLH). This may help lower green hydrogen

14 The economic geographer Alfred Weber, in his *Theory of the Location of Industries*, first published in 1909, introduced the distinction between natural and man-made locational advantages. Natural locational advantages are inherent to a location and cannot be replicated elsewhere, for example proximity to raw materials, favourable climate or access to natural harbours. Man-made locational advantages: These are created through human effort and investment, such as infrastructure (roads, railways), skilled labour availability or government incentives.

production costs. Additionally, Uruguay has access to the Port of Montevideo and a robust and diversified electricity grid managed by UTE.[15]

Because the country has no domestic energy resources of its own, before and during the first half of the 20th century, Uruguay depended on imported energy carriers (coal, oil and gas) to meet its needs. In 1948, the first hydroelectric power plant (Rincón del Bonete Dam) was inaugurated on the Rio Negro. Between 1960 and 1982, three more plants were built, the largest of which (Salto Grande Dam, 1979, 1,890 MW) is shared by Argentina and Uruguay. Although hydropower still accounts for around 48% of electricity production, Uruguay has largely exhausted its hydroelectric potential. In addition, increasing variability in rainfall patterns has made hydropower vulnerable and prompted a shift towards diversification through non-traditional renewable energy sources.

The transition to non-traditional electricity generation started with the approval in 2008 of the "National Energy Policy 2005-2030". The policy focused on energy independence, sustainability and affordability. It prioritised diversification of the energy matrix with a strong focus on renewables. Important instruments implemented subsequently include technology-specific auctions for renewable energy projects and 20-year power purchase agreements with guaranteed prices (feed-in tariffs), which attracted private investment in the energy sector. In 2010, all political parties represented in Congress endorsed the national energy policy (IRENA, 2015, p. 3). This agreement gave private investors confidence that the scope for action would not fundamentally change even following a change of government. This proved to be true over the following 15 years. The combination of bold public policies and an attractive climate for private investment made Uruguay an internationally recognised example of a swift energy transition. Between 2008 and 2015, private firms installed 581 MW of wind capacity. Between 2008/09 and 2022/23, wind energy's share of electricity generation rose from virtually zero to 43%, while that of hydropower decreased from 49% to 33% and that of fossil fuels from 48% to 12% (Leitzell, 2025). In years with average or above-average rainfall, the country now generates around 98% of its electricity from renewable energy sources (Markert, 2026).

Despite these remarkable successes, the picture looks less bright when looking at the overall energy matrix. According to IEA data, fossil fuels (primarily oil and derivatives) still account for 39% of the energy mix (IEA, s.a.-a). Oil and derivatives are mainly used in transport and industry. Both sectors account for around 10% of Uruguay's GHG emissions. Major energy-consuming industries include:

- Pulp and paper industries – Uruguay is a global exporter of pulp produced mainly from eucalyptus trees. These facilities consume substantial energy for wood processing, drying and chemical treatment. Many use biomass for cogeneration, producing both electricity and steam on-site.

- Cement industry – Cement production requires high-temperature furnaces, making it one of the most energy-intensive sectors. Plants in Uruguay use natural gas and alternative fuels, including waste-derived biomass.

- Food processing – Uruguay's strong agricultural base supports meat, dairy and grain processing. Energy is used for refrigeration, sterilisation, drying and packaging. Some facilities generate biogas from organic waste, improving energy efficiency.

Uruguay's *transport sector* still relies on fossil fuels and is the main source of GHG emissions. Heavy-duty vehicles and buses, which represent 4% of the country's total fleet, are responsible for 36% of the emissions and are difficult to electrify (CEIC, s.a.). Many interviewees agreed that developing GH_2 and its derivatives was an opportunity to support the decarbonisation of heavy-

15 The official name is Administración Nacional de Usinas y Trasmisiones Eléctricas.

duty transport and industry. This was also described as the second (or fourth, depending on the way of counting) energy transition. Indeed, two of the green hydrogen projects currently being implemented target heavy-duty transport (e.g. the H24U and Kahirós projects, see Table 3).

4.2.2 Opportunities for local value creation and for the domestic market

Most interviewees recognised the importance of assessing the impact of green hydrogen development in the country, emphasising the need to adopt a more inclusive model that delivers benefits and supports long-term national development. They highlighted the need for an approach that combines attracting foreign investment with strengthening local capacities. In addition, they stressed the importance of involving academia and communities in this process. This would require the development of new skills, investment in infrastructure and the promotion of technological progress, all essential to making green hydrogen production viable while also delivering broader national benefits.

Drawing on experience from previous transitions, interviewees expected that the production of GH_2 and its derivatives would enable Uruguay to achieve greater technological capabilities, facilitating access to highly competitive markets. In the initial stage, the greatest potential could lie in the production of high-value hydrogen derivatives, such as methanol and aviation fuels. In the longer term, ammonia production might be an option, although many interviewees considered it less competitive at the regional level. Green hydrogen production might foster local industrial development, especially in the forestry sector, for instance, in transport, where there are already two promising pilot projects for converting diesel trucks to run on fuel cells. Another potential application mentioned was pulp bleaching. Hydrogen peroxide (H_2O_2) is already widely used in industrial pulp bleaching as a relatively environmentally friendly oxidising agent that brightens pulp by breaking down lignin.

In addition, interviewees also foresaw producing nitrogen fertiliser from ammonia, which could reduce costs for local agricultural production. Uruguay imports more than 1 Mt of fertilisers annually, predominantly nitrogen-based and phosphate fertilisers (Ministerio de Desarrollo Social, s.a.). In 2022, the total import value exceeded USD 400 million (Observatorio de Complejidad Económica, s.a.).

For most interviewees, certifying GH_2 across the production chain represented one of the main uncertainties. As in the international market (mainly in the EU), it was not clear what would qualify as “green”, given that Uruguay would use biomass for this production.[16]

To anticipate and overcome these potential challenges, Uruguay, along with other countries in the region such as Paraguay, has been working since 2023 on the certification of GH_2 (CertHiLAC; see Box 4). During the initial stage, the certification is intended to operate at the regional level, covering the quality of hydrogen production, storage and derivatives, with international recognition sought in a second stage. The aim is to cover the entire market value chain and minimise complexities that could arise in the export market, given the anticipated importance of export demand.

Although certification represents a challenge, it also offers the possibility of creating new capacities, as these processes require specialist skills at each stage (e.g. technicians, engineers and operators). Some interviewees highlighted that Uruguay, in addition to offering greater legal certainty for companies wishing to invest in green hydrogen production, had a more developed regulatory framework than Chile.

16 The EU’s Renewable Energy Directive III (RED III), adopted in late 2023, allows biomass to be used for hydrogen production, but only under strict sustainability and GHG reduction criteria.

4.2.3 Environmental and social issues

Most interviewees emphasised the importance of conducting ESIAs, especially concerning groundwater resources such as aquifers. They are crucial reserves of freshwater for the region, supporting both human consumption and key economic activities, such as cattle farming.[17] ESIAs should not be seen as a burdensome obligation for internationally financed energy and hydrogen projects, but rather as a valuable source of information and knowledge for project developers and policymakers. This knowledge may inform public policies to ensure the sustainable use of natural resources and reduce the risk of opposition from some segments of the population, such as agricultural producers and social groups.

Experience to date indicates that a lack of social licence combined with stringent regulatory oversight can make the implementation of large-scale hydrogen projects extremely difficult, time-consuming or impossible. Uruguay's experience in transitioning to wind energy illustrates a model in which private investment has been crucial, while government oversight was important in ensuring that the generated renewable energy would be purchased and investments protected. However, some interviewees criticised the model because it could lead to a loss of energy sovereignty and limit the participation of local communities.

The development of GH_2 in Uruguay should address these issues to achieve a more inclusive and sustainable model. Involving local communities could help minimise negative externalities in the future, as these communities can be valuable allies in channelling investment towards initiatives that benefit all stakeholders. Local communities demanded a clear plan to promote local production and capacity development in the green hydrogen sector. Otherwise, Uruguay might miss the opportunity to maximise the benefits of this new industry, becoming an export-oriented green hydrogen "enclave", in which production plants are installed with the sole purpose of exporting the product, with limited benefits for the domestic economy.

It was considered crucial for these projects to promote local development and deliver tangible benefits for society as a whole, particularly for the local communities in areas where these projects are planned. Additionally, this would allow for the development of new skills and capacities, which could change the perceptions that many local stakeholders had about these projects at the time, as they were often seen as being extractive and providing few job opportunities.

17 As background to the conflicts around the Tambores project, Uruguay faced its worst drought in more than 70 years in 2022/23, leading to severe water shortages, especially in Montevideo. In 2023, the government declared a water emergency. This background is not intended to downplay the concerns and criticisms expressed in the workshop discussed in Section 4.2 in any way.

Box 5: Recent conflicts around two large green hydrogen projects in Uruguay

As of August 2026, there were two large-scale projects at an advanced planning stage, while a third one was announced in early 2024 but remains at an early planning stage. The two more advanced projects are being developed by the Chilean–American–German company HIF Global (Highly Innovative Fuels) and the German project developer Enertrag, while the third is being developed by the Saudi Arabian–Spanish company Alfanar. The HIF Global project will be located near the city of Paysandú in the department of the same name, while the Enertrag project is planned near the town of Tambores in the Department of Tacuarembó.

The HIF project in Paysandú was announced in June 2022, with a planned investment of USD 4 billion in a renewable energy and eFuels facility. The project aims to produce e-fuels from GH_2 and biogenic carbon in partnership with Alcoholes del Uruguay (ALUR), a subsidiary of Uruguay's state oil company ANCAP. Engineering and environmental studies were conducted, and plans were developed for a large-scale facility with a substantial land and infrastructure footprint. In July 2025, in response to community and environmental concerns, HIF Global announced a 35% reduction in the project's land requirements and a 70% reduction in its impact on native forests. The planned locations of the chimneys have been adjusted to reduce their visibility from the facility perimeter, including from across the border in Argentina. Uruguay's Ministry of Environment has not yet granted full approval due to concerns about the project's water use and its impacts on native forests and biodiversity. The project has been described as having a "significant negative environmental impact", requiring additional mitigation measures and public consultation before it can proceed. In October 2025, HIF Global started a new consultation process to improve its approach to environmental management. Despite these setbacks, HIF Global maintains its investment plans and intends to begin construction in the second half of 2026 and switch on the eFuels facility in 2029.

In May 2022, Enertrag AG announced plans to develop a green hydrogen hub in Tacuarembó, Uruguay. In 2023, Enertrag began technical and environmental feasibility studies and started land acquisition processes in the Tambores region. Local groups began to question the project's design and potential benefits for the local population. They criticised plans for large-scale water withdrawal from the Guaraní aquifer, an important freshwater reserve for the region. In March 2025, Uruguay's Dirección Nacional de Calidad y Evaluación Ambiental formally rejected the project's ESIA. The project is on hold. This decision was based on a lack of essential technical and environmental information, particularly regarding water consumption.

4.2.4 Political, regulatory and institutional aspects

In Uruguay, private-sector involvement has been essential in the transition to wind energy, supported by strong state intervention that ensures energy acquisition and protects investments. This is due to the country's robust institutional framework, which stands out as one of its main competitive advantages over other countries in the region. However, the transition to GH_2 presents both opportunities and challenges for Uruguay. Success will depend on the country's ability to manage the process efficiently, drawing on lessons learnt from previous energy transitions and ensuring the active participation of all stakeholders, as well as striking a balance between economic viability and environmental sustainability.

Several interviewees highlighted the importance of international cooperation in achieving an equitable and sustainable energy transition, expressing support for the development of GH_2. They proposed a system of payments for the use of natural resources such as water, wind and sunlight in green hydrogen production, with the aim of generating revenue for producing countries to invest in technological development and thereby reduce their dependence on foreign technology. Such a payment system would aim to ensure that countries in the Global South benefit from green hydrogen production.

If Uruguay manages to provide the necessary guarantees for hydrogen production and maintains them over time, it might be able to attract investment that drives the development of new technologies and infrastructure required for this process. These advancements are expected to benefit other sectors of the economy, especially in terms of technological development and innovation. This is based on experience from previous energy transitions, which, while relying on foreign investment, generated long-term benefits for the country. In this regard, the institutional framework and all sectors of society play a central role in shaping these processes to ensure that investment is not limited to "turnkey" projects that exclude domestic actors from decision-making. There was a broad consensus among the stakeholders interviewed that it was essential to ensure that hydrogen production was green and sustainable to secure long-term competitiveness in the hydrogen market. Many considered international collaboration essential to achieving an equitable and sustainable energy transition.

5 Summary and recommendations for national policy and international cooperation

Germany, Argentina and Uruguay share an interest in making the global hydrogen economy a reality. **First**, there is the undisputed need to reduce GHG emissions as fast as possible. This must include emissions from "hard-to-abate" industries and sectors, where electrification may not be technically feasible and where LEH_2 would have to play a role. **Second**, there are shared economic and social objectives. For instance, Germany has invested considerable financial resources in funding mechanisms to subsidise the transition of its steel production from coke to lower-emission fuels and feedstocks. Once these facilities are operational, there will be a substantial demand for LEH_2. If this demand is not met, the plants will operate with natural gas. Such shifts are technically feasible, but they are inconsistent with net zero ambitions.

5.1 Changes and continuities in the political settings

Shortly after the research team that prepared this report finished its empirical work in June 2024, EU citizens elected a new European Parliament. In February 2025, Germany held national elections. In both elections, parties strongly committed to environmental and climate protection lost support, while parties with a more "business as usual" position and/or right-wing agenda gained ground. While this has led and will continue to lead to some changes in energy and economic policies, the overall policy orientation remains intact, including Germany's goal to become climate-neutral by 2045. Similarly, the EU broadly remains committed to the European Green Deal, launched in 2019. The Green Deal is the EU's strategy to achieve climate neutrality by 2050 through sustainable growth, clean energy and environmental protection. These political developments, including the new US policy agenda, have influenced the decisions of economic actors. Faced with the prospect of postponed sectoral decarbonisation targets, less ambitious emissions reduction commitments and limited subsidies for the sector, many companies have shown greater caution in moving forward with their clean technology investment plans.

Argentina underwent a change of government at the end of 2023. Thereafter, the leadership of the Energy Secretariat was replaced, and some hydrogen policy guidelines were discontinued. The political agenda places less emphasis on climate change mitigation and adaptation. Argentina's latest NDC submission shows a lower emissions reduction requirement, due to changes in the calculation methodology, and focuses on strengthening the framework for carbon markets.

Uruguay held elections in 2024. As the main elements of the energy reforms are based on a cross-party agreement, the change in government has not led to significant modifications in

these policy areas. The government reaffirmed its commitment to climate action and adaptation by submitting its third NDC review in December 2024.

For countries in the Global South, producing H_2 and derivatives for both international and domestic markets might offer opportunities to generate economic value and create jobs. Observers and researchers see Germany as a major future consumer of H_2, alongside Korea and Japan. Argentina and Uruguay are both seen as potential suppliers of LEH_2 and derivatives to global markets. However, after the first quarter of 2026, the anticipated ramp-up of a global green hydrogen economy has not materialised and is not yet discernible. Initiating this expansion will require further ambitious measures by national governments and regional bodies, such as the European Commission. Without this, the apparently straightforward alignment of hydrogen production in the Global South with consumption in the Global North for mutual benefit is called into question.

The 75 interviews conducted by the research team that compiled this study in Argentina and Uruguay between February and April of 2024 helped clarify some of the challenges facing countries of the Global South, despite the differences between the two countries. Stakeholders in both countries placed emphasis on export opportunities as a potential catalyst for developing the hydrogen economy in their country. Most did not see low-emission hydrogen projects aimed at serving local markets as an important business or policy case. Only some stakeholders in Argentina considered the domestic market relevant to learning processes to become “export-ready”. The country has a substantial domestic industrial base and decarbonising long-distance transport may be a relevant issue. In Uruguay, a geographically small country whose economy is mainly based on services, agriculture and livestock farming, the options for local use of H_2 are far more limited. They can be found, for example, in the forest plantation sector and related pulp industry, where two promising projects for hydrogen derivatives are under way, taking advantage of the biogenic CO_2 emissions from pulp production.

The fact that the development of a hydrogen economy has largely stalled places a special responsibility on countries that may be future net importers of LEH_2. This is especially the case for Germany, which has played a leading role in shaping the debate on LEH_2 in Europe. A responsible approach requires a commitment to open and transparent communication among all relevant stakeholders about the opportunities and challenges associated with the low-emission hydrogen economy, including changes in political priorities. In 2024 and 2025, some fundamental shifts in the debate require actors in Germany, Argentina and Uruguay to reassess their priorities both collectively and individually. Confidence in the prospects for the hydrogen economy has declined considerably, leaving many projects across the hydrogen value chain without an FID, delayed or cancelled. Potential hydrogen consumers have proved to be very cost-sensitive and the scope for public subsidies has narrowed considerably in the wake of economic stagnation and an increased focus on austerity policies in Germany and other European countries.

We do not anticipate the emergence of substantial value chains linking hydrogen production in South America to end use in Europe in the near future. This primarily reflects the basic economics of the emerging hydrogen economy. International evidence indicates that the unit costs of LEH_2 (usually measured in USD/kg of H_2) are now much higher than anticipated a few years ago, when countries such as Chile adopted ambitious green hydrogen strategies. Added to this are the costs of converting H_2 into derivatives that are easier to transport, such as ammonia or methanol, and potentially converting these derivatives back into molecular H_2. These additional steps will significantly increase landed costs at the port of destination compared to the production costs in Argentina and Uruguay. This reduces the competitiveness of the Southern Cone relative to competitors that could supply Central Europe by pipeline, such as those in Norway or North Africa.

This situation considerably alters export prospects, but it may offer an opportunity for South American countries to plan the development of a hydrogen economy differently from approaches pursued in recent years. This means not only meeting demand in the Global North but also addressing local clean energy needs, for example to meet demand from multinational companies operating in both countries and to facilitate the export of manufactured goods (Robert, Cretini, & Prados, 2025). Given the decline in confidence in the hydrogen economy, we assume that European actors will focus in the coming years on smaller, often domestic projects or production in neighbouring countries, prioritising less complex projects with lower risks. We expect a corresponding shift in the priorities of actors in the Global South, particularly in the Southern Cone.

Much remains in flux with regard to the hydrogen economy and the technologies underpinning it. Therefore, we do not rule out the possibility that global hydrogen value chains may emerge in the future. This could be the case, for example, if significantly cheaper methods for producing, storing and transporting H_2 and its derivatives are developed. The gap between the production and import costs might shrink. Until there is a clear prospect of such cost reductions, our policy recommendations focus on “no-regret” options over a medium-term horizon.

5.2 Conclusions for national policies, regional and international cooperation

It is five years since Germany adopted its NHS, and around two years since hydrogen-related cooperation was initiated via an MoU in the case of Uruguay, and a call for proposals for project funding in the case of Argentina. A range of activities has been initiated since then and many of them continue. Some are driven by local actors (such as the Kahirós and H24U projects in Uruguay), while others are collaborative, for example within the framework of the PtX Hubs in both countries. At the time of finalising this report, the more ambitious H_2 projects driven by international investors (Tambores/Enertrag and Paysandú/HIF in Uruguay) are facing difficulties with local authorities reluctant to confirm the environmental and social compatibility of the projects. Given these uncertainties, we make the following recommendations:

1. In a field as dynamic as the hydrogen economy, it is especially important to **overcome information asymmetries** between actors in the Global North and the Global South and to engage in early, sustained and open communication about plans, expectations, uncertainties and concerns. Such communication is essential to avoiding or overcoming obstacles, foster a sense of ownership among affected communities and find creative solutions to challenges. Some interviewees argued that in the preceding years German and European hydrogen diplomacy had created unrealistic expectations regarding potential hydrogen exports in terms of volumes, prices and timeframes.

2. Germany and Europe should partner with Argentina and Uruguay to explore how large-scale H_2 projects can be designed in an **environmentally friendly and resource-saving way** (e.g. water and land) and integrated into national energy systems. The potential impacts of hydrogen production on water resources are particularly sensitive. If projects face resistance from local communities or NGOs, this can lead to reputational damage and may delay or even jeopardise approval procedures.

3. Establishing low-emission hydrogen value chains involves **knowledge-intensive steps** and includes some elements with relatively low levels of technological readiness, such as cost-effective small-scale electrolysers. There is already a relevant knowledge base in the region on which to build. Hydrogen technologies are not entirely out of reach for Argentina and Uruguay. Argentine research groups have developed an alkaline electrolyser, using local expertise and resources. Argentina, Uruguay and other countries in Latin America should

expand and strengthen the knowledge base on LEH_2 and develop small-scale projects that enable capacity building while addressing local decarbonisation needs. The knowledge mobilised should include not only technical and engineering fundamentals but also knowledge of how to reduce the environmental footprint of H_2 projects and how to maximise benefits for local communities, for example in terms of equitable access to employment with decent working conditions.

4. For GH_2, the **siting of the renewable energy** component may be crucial to make a low-emission hydrogen project economically feasible. The cost of H_2 produced via electrolysis does not depend solely on the costs of physical infrastructure (electrolysers and balance of plant). A further decisive factor is the operating time of electrolysers, measured in FLH. The higher the number of FLH achieved, the lower the levelised cost of H_2. While investment costs for electrolysers and balance of plant remain high, achieving high FLH through wind power, solar power or an optimised combination of the two is particularly important. Achieving this optimisation is a knowledge-intensive process. In addition, detailed information is needed on the **availability and quality of groundwater and surface water** in the designated project regions to avoid conflicts over water use. For BH_2, project developers must assess geological formations that could be used to store CO_2. This implies that a broad range of technical and scientific knowledge is needed to support the sustainable ramp-up of the hydrogen economy. These disciplines range from engineering, geosciences, meteorology, hydrology and biology to economics, labour studies and gender studies.

5. We see a clear need to **strengthen R&D efforts in both countries**. The first priority is to increase R&D spending with greater private-sector participation. In 2022, Argentina spent 0.55% of its gross domestic product on R&D and Uruguay 0.63%. Both figures are well below the 1.0% benchmark cited by UNESCO, widely recognised as the minimum threshold for countries to build a sustainable research and innovation base. R&D expenditure is measured by SDG 9 (UNESCO, s.a.). R&D expenditure in Argentina and Uruguay is well below the 2022 averages for upper-middle-income countries (2.14%) and high-income countries (2.92%), which should be the benchmarks for both countries (World Bank, 2025). A second priority in developing a knowledge-based hydrogen economy is to sustain and expand international research cooperation in specific and strategic areas. The considerable attention paid to H_2 in recent years has stimulated a number of joint research projects, including those involving Germany, Argentina and Uruguay. It was not possible to determine conclusively whether or not Argentina and Uruguay can develop proprietary technologies related to LEH_2.

6. The topic of hydrogen is rather new in Latin America, and many countries in the region are interested in its development, mostly still focusing on linking their future production to overseas markets rather than to regional ones (see Robert, Cretini, & Prados, 2025). This calls for stronger **regional or continent-wide cooperation**. We recommend that regional policymakers consider establishing a *transnational centre of excellence for LEH_2*. Such a centre could be established on the basis of the Centro Latinoamericano de Biotecnología (CABBIO) model, which is a network of biotechnology research groups and promotes the implementation of joint R&D projects and advanced training for researchers and professionals. A Latin American centre of excellence for LEH_2 could go beyond this, particularly given the field's relative novelty and the small number of research groups that are currently established within it. This might require a central institution with dedicated premises. The centre could monitor international R&D developments in relevant technological fields and identify strategic options, in consultation with private-sector actors and civil society stakeholders. Demonstration facilities could be established to support technological development and innovation. Additional functions could include technology foresight, technology assessment and the incubation of hydrogen-related start-ups.

7. Hydrogen projects can significantly affect people's living environments, for example when renewable energy generation has to be scaled up. Communities in affected regions have to

be “brought on board” as early as possible and both expectations and concerns must be taken seriously. **Proactive and sustained communication** by international project developers and national governments can be critical to the success of hydrogen projects. The management of expectations regarding the hydrogen ramp-up (volumes, prices, timeframes) has not been adequate in the past. Both unrealistic expectations and exaggerated fears were generated. These shortcomings should be addressed in future through better communication.

8. In addition, it may be crucial to **generate co-benefits for the local population**, particularly if the project creates few jobs or mainly temporary employment. For instance, where seawater desalination plants are planned (e.g. in arid regions of Patagonia), building oversized plants could provide water for irrigated agriculture in the region. Interviewees in Uruguay suggested considering a charge for water extracted for export-oriented hydrogen production, to be paid by importing countries. The funds raised could be invested in productive activities that create jobs in the area hosting the project. In water-scarce areas such as Bahía Blanca or Chubut in Argentina, one option for generating local co-benefits would be to “oversize” seawater desalination plants and use the surplus water for irrigated agriculture or to meet the water needs of the local population, for example.

9. At the end of 2023, Latin America took an important step **towards regional cooperation on LEH_2** when 12 government representatives signed a declaration entitled “Decarbonising LAC” and CertHiLAC was announced. This is a **certification system** for clean and low-carbon hydrogen production in Latin America and the Caribbean. It receives support from the IDB and OLADE. A Joint Declaration by CertHiLAC and the IEA further strengthened its international recognition. CertHiLAC should be further strengthened and developed. It is an encouraging example of regional cooperation on LEH_2. Some of the interviewees believed there were more far-reaching options for regional cooperation, for example given the countries’ complementary strengths and needs and the scope to build on existing agreements in the MERCOSUR region. This could lead to a regional hydrogen market, the development of low-emission hydrogen technologies within the region and reduced dependence on imports from outside the region.

10. Many stakeholders in both countries mentioned the need to have at least one **operational low-emission hydrogen pilot project**. Only in this way would it be possible – through a “learning-by-doing” approach – to gather information about future needs, for example for developing low-emission hydrogen standards and defining a regulatory and research agenda. Such pilot projects could be linked with the above-mentioned centre of excellence, with the support of an international organisation that coordinates activities in the region. For example, building on the successful collaboration between OLADE and the IDB under CertHiLAC, a joint programme with UNIDO, OLADE and the IDB could be considered.

International cooperation between Germany and Europe and the Southern Cone countries

The main mechanisms for hydrogen-related cooperation between Germany, Argentina and Uruguay are the **PtX Hubs** active in both countries and the **H2-related activities of the AHK**. PtX Hubs began operating in Uruguay in 2018 and in Argentina in 2021/22. Their activities are closely aligned with the concept of a knowledge-based hydrogen economy. The hubs finance studies, seminars and events that support ministries and other local stakeholders in designing and further developing the hydrogen strategies and roadmaps. Similarly, sometimes in close cooperation with the PtX Hubs, the AHK organises forums on H_2, trainings and inbound as well as outbound delegation visits. The chambers of commerce see themselves as bridges between local stakeholders and German industry, ensuring knowledge transfer, investment opportunities

and policy alignment. Both cooperation mechanisms involve close collaboration with national partners and can therefore be regarded as demand-driven, cost-efficient and flexible.

The World Bank classifies Argentina as an upper-middle-income country and Uruguay as a high-income country; both countries are therefore **not eligible to cooperate financially** with Germany or Europe, or receive access to preferential finance instruments, for example from the World Bank. At present, Argentina is included in the DAC List of ODA Recipients, whereas Uruguay is not (Organisation for Economic Co-operation and Development, s.a.). This implies, for instance, that private German companies might receive support through the develoPPP facility for projects that contribute to sustainable development in Argentina (develoPPP, s.a.). Cooperation projects on LEH_2 may be eligible for support through **international climate finance instruments, research funding or both**. For instance, under the EU's Horizon Europe programme, including under Pillar II ("Global Challenges and European Industrial Competitiveness"), Argentina is eligible as a third country, and Uruguay is eligible with certain restrictions (European Commission, s.a.-b).

With funding from the German Federal Ministry of Research, Technology and Space (BMFTR), the German Metrology Institute (PTB) is implementing a cooperation project with Argentina's INTI: the "German-Argentinian partnership to harmonise standards for hydrogen quality and origin" (HyGAP). The kick-off meeting took place in Buenos Aires in March 2025. HyGAP focuses on the exchange of experience and knowledge transfer on methods required to analyse and specify H_2 in accordance with ISO 14687 ("Hydrogen fuel quality – Product specification").

One example of potential **innovation-oriented cooperation** between Argentina, Uruguay and Germany mentioned by interviewees would be the development of affordable small-scale electrolysers that can be scaled up. Similarly, cost-effective and efficient solutions for hydrogen logistics (transport and storage) adapted to the region's geographical and geological conditions could offer promising opportunities for international cooperation, including business-to-business linkages with or without public support.

The Fraunhofer Society for the Advancement of Applied Research (FhG) is currently implementing a cross-institutional project entitled "AmmonVector", which addresses the entire ammonia value chain, focusing primarily on decentralised approaches to ammonia synthesis and use (Fraunhofer, 2026). Universities as well as research and innovation institutes in Argentina and Uruguay could explore opportunities to collaborate with FhG institutes on topics related to LEH_2, for example manufacturing nitrogen fertilisers based on LEH_2.

Germany should cooperate with **higher education, science and technology institutions** in Argentina and Uruguay working on RE and LEH_2. In Africa, the BMFTR has significantly contributed to the establishment of SASSCAL (s.a.) and WASCAL (s.a.-a). A comparable institution could be established in the South American region, for example the proposed transnational centre of excellence for LEH_2. Following the WASCAL model, joint master's programmes with European universities could be established (WASCAL, s.a.-b). Establishing relevant technical and vocational education and training programmes could form part of this broader endeavour to develop skills and expertise.

References

Aimikhe, V., & Oghenegare, E. E. (2023). Recent advances in white hydrogen exploration and production: A mini review. *Journal of Energy Research and Reviews, 13*(4), 64-79.

Bertoni, R., & Messina, P. (2023). The “wind revolution” in Uruguay and the role of the public sector in guiding energy transitions. In L. L. B. Lazaro & E. Serrani (Eds.), *Energy transitions in Latin America. Sustainable Development Goals series*. Springer.

BioEconomía.info. (2024, 5 February). *Uruguay decidido a convertirse en un centro de innovación en Bioeconomía*. https://www.bioeconomia.info/2024/02/05/uruguay-decidido-a-convertirse-en-un-centro-de-innovacion-en-bioeconomia/

BMWi (Bundesministerium für Wirtschaft und Energie). (2020). *Die Nationale Wasserstoffstrategie*. https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf

BMWK (Bundesministerium für Wirtschaft und Klimaschutz). (2023). *Fortschreibung der Nationalen Wasserstoffstrategie.* https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Publikationen/Energie/fortschreibung-nationale-wasserstoffstrategie.pdf

Casaravilla, G., & Chaer, R. (2021, Fourth Quarter). Energy transition of Uruguay. *IAEE Energy Forum*, 11-14. https://www.colibri.udelar.edu.uy/jspui/handle/20.500.12008/29730

CEIC. (s.a.). *Uruguay total greenhouse gas emissions: Tonnes of CO2 equivalent per year: Transport.* https://www.ceicdata.com/en/uruguay/environmental-greenhouse-gas-emissions-annual/total-greenhouse-gas-emissions-tonnes-of-co2-equivalent-per-year-transport

Culshaw, F. (2022, 21 August). Hidrógeno verde. *El País.* https://www.elpais.com.uy/negocios/noticias/cuales-son-las-empresas-interesadas-en-producir-hidrogeno-verde-en-uruguay

Dean, S. (2025, 8 June). *The wind energy hub that is transforming Argentina*. https://valiantbrokers.com/patagonia-wind-energy-hub-that-transforms-argentina/

develoPPP. (s.a.). *Investing responsibly. Promoting development. For more than 25 years.* https://www.developpp.de/en/

Dialogue Earth. (2025). *Uruguay expande la energía solar a medida que aumenta la demanda de electricidad*. https://dialogue.earth/es/energia/uruguay-expande-energia-solar-aumenta-demanda-electricidad

Diputados Argentina. (2024). *Proyecto de Ley.* https://www4.hcdn.gob.ar/dependencias/dsecretaria/Periodo2024/PDF2024/TP2024/5855-D-2024.pdf

Diputados Argentina. (2025). *Proyecto de Ley.* https://www4.hcdn.gob.ar/dependencias/dsecretaria/Periodo2025/PDF2025/TP2025/3503-D-2025.pdf

European Commission. (s.a.-a). *Renewable hydrogen*. https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen/renewable-hydrogen_en?utm_source=copilot.com

European Commission. (s.a.-b). *List of participating countries in Horizon Europe*. https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/list-3rd-country-participation_horizon-euratom_en.pdf

Fraunhofer. (2026). *Fraunhofer flagship project “AmmonVektor”.* https://www.ammonvektor.fraunhofer.de/en.html

Fuel Cells Works. (2025, 23 July). *Cancelled and postponed green hydrogen projects.* https://fuelcellsworks.com/2025/07/23/energy-development/cancelled-and-postponed-green-hydrogen-projects?

Gläser, J., & Laudel, G. (2010). *Experteninterviews und qualitative Inhaltsanalyse*. VS-Verlag.

HIF Global. (2025, 24 June). *HIF Global advances assembly of innovative direct air capture technology in Chile.* https://hifglobal.com/media/news-description/2025/06/24/hif-global-advances-assembly-of-innovative-direct-air-capture-technology-in-chile?utm_source=copilot.com

IEA (International Energy Agency). (2019). *The future of hydrogen.* https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf

IEA (2023a). *Global hydrogen review 2023*. https://www.iea.org/reports/global-hydrogen-review-2023.

IEA (2023b). *Latin America energy outlook, overview: Argentina.* https://iea.blob.core.windows.net/assets/1fe309e7-95f1-48a8-b32f-4bea94de4fbe/Argentinaenergyprofile_EN.pdf

IEA (2024a). *Global hydrogen review 2024*. https://www.iea.org/reports/global-hydrogen-review-2024

IEA (2024b). *Electrolysers*. https://www.iea.org./energy-system/low-emission-fuels/electrolysers.

IEA (2025). *Global hydrogen review 2023*. https://www.iea.org/reports/global-hydrogen-review-2025

IEA (s.a.-a). *Energy system of Uruguay.* https://www.iea.org/countries/uruguay

IEA (s.a.-b). *Uruguay: Electricity.* https://www.iea.org/countries/uruguay/electricity

IRENA (International Renewable Energy Agency). (2015). *Renewable energy policy brief.* https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_RE_Latin_America_Policies/IRENA_RE_Latin_America_Policies_2015_Country_Uruguay.pdf

Leitzell, J. (2025). Learning from Uruguay's energy transition [Blog post]. Kleinman Center for Energy Policy. https://kleinmanenergy.upenn.edu/commentary/blog/learning-from-uruguays-energy-transition/

Lempert, R. J., Popper, S. W., & Bankes, S. C. (2003). *Shaping the next one hundred years: New methods for quantitative, long-term policy analysis*. RAND Corporation. https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR1626.pdf

LowCarbonPower. (s.a.). *Electricity in Argentina in 2025*. https://lowcarbonpower.org/region/Argentina

Markert, S. (2026, 6 April). *The Uruguay way: Achieving energy sovereignty in the developing world*. Earth. https://earth.org/the-uruguay-way-achieving-energy-sovereignty-in-the-developing-world/

McNamara, A. (2025, 28 March). Uruguay's democracy: A model for stability in Latin America. *Harvard International Review*. https://hir.harvard.edu/uruguays-democracy-a-model-for-stability-in-latin-america/

Méndez, C. (2023, 28 February). Vecinos de Tacuarembó presentaron acción de inconstitucionalidad contra decreto departamental que permite instalación de planta de hidrógeno verde y metanol. *La Diaria ambiente.* https://ladiaria.com.uy/ambiente/articulo/2023/2/vecinos-de-tacuarembo-presentaron-accion-de-inconstitucionalidad-contra-decreto-departamental-que-permite-instalacion-de-planta-de-hidrogeno-verde-y-metanol/

Merke, F. (2016). Argentina in a changing nuclear order – an appraisal. In T. Dalton, T. Kassenova & L. Williams (Eds.), *Perspective on the evolving nuclear order.* Carnegie Endowment for International Peace. https://carnegieendowment.org/files/NuclearPerspectives_final.pdf

Ministerio de Desarrollo Social. (s.a.). *Importaciones de fertilizantes. Total país.* https://www.gub.uy/ministerio-desarrollo-social/indicador/importaciones-fertilizantes-total-pais

MIEM (Ministerio de Industria, Energía y Minería). (2022). *Green hydrogen roadmap in Uruguay.* https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/green-hydrogen-roadmap-in-uruguay

MIEM. (2023). *Uruguay da importante paso hacia el desarrollo del hidrógeno verde con la concreción del primer proyecto piloto.* https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/uruguay-da-importante-paso-hacia-desarrollo-del-hidrogeno-verde-concrecion

MIEM. (2025, 25 April). *Uruguay vuelve a registrar niveles récord de fuentes renovables en la matriz de generación eléctrica.* https://www.gub.uy/ministerio-industria-energia-mineria/comunicacion/noticias/uruguay-vuelve-registrar-niveles-record-fuentes-renovables-matriz-generacion

Ministerio de Justicia Argentina. (2006, 25 August). *Promocion del hidrogeno: Declarase del interes nacional. Ley 26123.* https://www.argentina.gob.ar/normativa/nacional/ley-26123-119162/texto

Observatorio de Complejidad Económica. (s.a.). *Fertilizantes en Uruguay.* https://oec.world/es/profile/bilateral-product/fertilizers/reporter/ury

Organisation for Economic Co-operation and Development. (s.a.). *ODA recipients: Countries, territories, and international organisations*. https://www.oecd.org/en/topics/sub-issues/oda-eligibility-and-conditions/dac-list-of-oda-recipients.html

Ponce, J. C. (2024, 18 December). *Uruguay, pioneer in renewable energy: A model for the world?* Yale Climate Connections. https://yaleclimateconnections.org/2024/12/uruguay-pioneer-in-renewable-energy-a-model-for-the-world/

RAND. (s.a.). *Decision making under deep uncertainty.* https://www.rand.org/global-and-emerging-risks/centers/pardee/dmdu-decision-making-under-deep-uncertainty.html

Robert, V., Cretini, I., & Prados, P. (2025). *Condiciones estructurales para las políticas de transformación productiva en la industria del hidrógeno de bajas emisiones en América Latina y el Caribe.* Documentos de Proyectos (LC/TS.2025/108). Comisión Económica para América Latina y el Caribe.

SASSCAL. (s.a.). Homepage for Southern African Science Service Centre for Climate Change and Adaptive Land Management. https://sasscal.org/

Senado Argentina. (2024). *Número de Expediente 1714/24.* https://www.senado.gob.ar/parlamentario/comisiones/verExp/1714.24/S/PL

Shackle, G. L. S. (1949). *Expectations in Economics*. Cambridge University Press.

SKYNRG. (s.a.). *Technology basics.* https://skynrg.com/sustainable-aviation-fuel/technology-basics/

SSA (Secretariat for Strategic Affairs). (2023). *National strategy for the development of the hydrogen economy.* https://www.gasworld-intelligence.com/wp-content/files/uploads/uploads/documents/Argentina-2023-National-Strategy-for-the-Development-of-the-Hydrogen-Economy.pdf

Sun, Y. (2021). *Investment decision making under deep uncertainty in the context of offshore wind financing*. Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance. https://www.firm.fm/wp-content/uploads/2022/02/Paper-2-DeepUncert_WindoffShore_Report.pdf

UNESCO. (s.a.). UIS Databrowser. https://databrowser.uis.unesco.org/view#indicatorPaths=UIS-SDG9Monitoring%3A0%3AEXPGDP.TOT&geoMode=regions&geoUnits=&browsePath=SCIENCE_TECHNOLOGY_INNOVATION%2FUIS-SDG9Monitoring&timeMode=rangr&view=table&chartMode=multiple&tableIndicatorId=EXPGDP.TOT&chartHighlightSeries=&chartHighlightEnabled=true

WASCAL (West African Science Service Centre on Climate Change and Adapted Land Use). (s.a.-a). Homepage for West African Science Service Centre on Climate Change and Adapted Land Use. https://www.wascal.org

WASCAL. (s.a.-b). *2025 admissions into International Master Program in Energy and Green Hydrogen Technology (IMP-EGH): Georeseources (water, wind) and technology for hydrogen production.* https://wascal.org/2025-admissions-into-international-master-program-in-energy-and-green-hydrogen-technology-imp-egh-georesources-water-wind-and-technology-for-hydrogen-production/

World Bank. (2024). *Average precipitation in depth (mm per year) – Uruguay, Argentina.* https://data.worldbank.org/indicator/AG.LND.PRCP.MM?locations=UY-AR.

World Bank. (2025). *Research and development expenditure (% of GDP) – China.* https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=CN

World Nuclear Association. (2026, 5 June). *Nuclear power in Argentina.* https://world-nuclear.org/information-library/country-profiles/countries-a-f/argentina#nuclear-power-plants

YPF Luz. (s.a.). Conocé nuestros activos. https://www.ypfluz.com/Proyecto/ElQuemado

Zilla, C. (2024). *Javier Milei's ideology and policy: Libertarian populism in Argentina* (SWP Comment 2024/C 37). Stiftung Wissenschaft und Politik. https://doi.org/10.18449/2024C37

Appendix: Extract from an interview guideline (example for chambers of commerce in Argentina)

A1 Introduction (brief description of the project and its objectives)

The purpose of the research is to understand perceptions, expectations, uncertainties, and challenges related to the emerging hydrogen economy in Argentina and Uruguay. Based on these findings, recommendations will be developed on how policy and international cooperation can support the development of a sustainable hydrogen economy.

A2 Informed consent: data collection and management procedures

Participation in this interview is voluntary. You may withdraw at any time and are not obliged to answer any sensitive questions. Your identity will remain anonymous, and your responses will be analyzed together with those of other participants. Transcripts will be stored securely. No identifiable information will be shared in publications. The data will be anonymized and archived for ten years. You will receive a summary of the results once the project is completed.

We would be very grateful if it were possible to record the conversation. This allows us to focus on what you are saying.

If you prefer not to be recorded, notes will be taken instead. The recording will be stored securely in accordance with EU and German data protection regulations and will not be accessible outside the research team.

A3 Interviewee background

a. Could you tell us a little about the background of your organization and, in particular, its involvement in the low-emission hydrogen industry? What is your role within the organization?

b. Has your organization’s perception of the potential impact of the low-emission hydrogen economy changed over the last five years? If so, was this change driven by any external event (positive or negative)?

A4 The low-emission hydrogen sector from a national and international perspective

a. How do you see national hydrogen production developing in Argentina in the near future?

b. Which hydrogen production pathways do you believe will be most relevant (green, blue, pink hydrogen), both in Argentina and globally?

c. Where in Argentina do you think the hydrogen economy is most likely to develop (which regions)?

d. Which market do you think will develop first: the domestic market, the export market, or both simultaneously?

e. Which sectors do you believe will be the first domestic consumers of hydrogen in Argentina? (e.g. steel, fertilizers, transport, others)

f. Which countries do you consider to be the most important export destinations for Argentina?

g. How do you view international competition (e.g. Chile, Brazil, Uruguay, the Middle East and North Africa, Australia) in hydrogen exports?

A5 Value chain opportunities

a. Do you think Argentina has opportunities to participate in the hydrogen value chain? In which segments do you see opportunities for local development and domestic production?

b. Are you aware of any initiatives involving collaboration with domestic firms? Or examples from other sectors that successfully integrated local companies (e.g. automotive, aerospace, renewable energy)?

A6 Challenges and uncertainties

a. What are the main barriers to entering the hydrogen market in Argentina? (e.g. capital, regulation, technology, suppliers, workforce, skills, environmental issues, infrastructure).

b. It is widely recognized that the hydrogen economy faces significant uncertainties worldwide. Which of these uncertainties are most important for Argentina?

c. How do these factors and uncertainties affect the project decisions of your members/partners?

d. At this stage, do you think it would be beneficial for your members to enter the market early? How do you envision this process from your organization’s perspective and in coordination with public and private stakeholders?

e. What is needed to scale up the hydrogen industry in Argentina?

A7 Role of government

a. Have you participated in, or are you familiar with, any national or provincial government programs or plans related to hydrogen?

b. How important are government actions (local, national, or foreign) for your organization? How do government policies (domestic or foreign) affect your organization and your members’ investment decisions?

c. What are the potential bottlenecks or factors that policymakers currently overlook or do not sufficiently consider?

d. How should governments (local, national, or foreign) engage to reduce uncertainties and/or address the bottlenecks currently facing the industry? Please specify the uncertainties and relevant policy actions (e.g. macroeconomic, regulatory, environmental, labor-related).

A8 Role of international cooperation

a. What do you see as the role of regional cooperation (e.g. among Brazil, Uruguay, Chile, and Argentina)?

b. How does cooperation among European chambers of commerce and business associations on hydrogen issues work?

c. What do you see as the role of international cooperation (e.g. in technological development, regulation, standards, etc.)? What actions should international cooperation actors take to reduce uncertainties?

A9 Closing the conversation

a. Is there anything else you would like to add or emphasize before we conclude the interview?

b. Do you think it would be important to interview any members of the chamber of commerce/ business associations on this topic?