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Designing an EU-Eligible Green Hydrogen Certification Pathway for Uruguay: RFNBO Alignment and an Auditable Social Safeguards Module

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List of Abbreviations

AAP	Autorización Ambiental Previa (Prior Environmental Authorization, Uruguay)
ALUR	Alcoholes del Uruguay
ANCAP	Administración Nacional de Combustibles, Alcohol y Portland (Uruguay)
ANII	Agencia Nacional de Investigación e Innovación (Uruguay)
BImSchG	Bundes-Immissionsschutzgesetz (German Federal Immission Control Act)
BMWE	Bundesministerium für Wirtschaft und Energie (German Federal Ministry for Economic Affairs and Energy)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
CAF	Corporación Andina de Fomento (Development Bank of Latin America and the Caribbean)
CARU	Comisión Administradora del Río Uruguay (Administrative Commission of the River Uruguay)
CCEE	Câmara de Comercialização de Energia Elétrica (Brazilian Electric Energy Trading Chamber)
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization and Storage
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CertHiLAC	Clean Hydrogen and/or Low Emissions Certification System in Latin America and the Caribbean
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COMAP	Comisión de Aplicación de la Ley de Inversiones (Uruguay)
CONACHA	Consejo de la Nación Charrúa (Council of the Charrúa Nation, Uruguay)
CSDDD	Corporate Sustainability Due Diligence Directive
CSRD	Corporate Sustainability Reporting Directive

DINACEA	Dirección Nacional de Calidad y Evaluación Ambiental (National Directorate for Environmental Quality and Assessment, Uruguay)
DINAGUA	Dirección Nacional de Aguas (National Water Directorate, Uruguay)
EAE	Evaluación Ambiental Estratégica (Strategic Environmental Assessment)
EC	European Commission
EH&S	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ESG	Environmental, Social and Governance
ESMAP	Energy Sector Management Assistance Program (World Bank)
EU	European Union
FPIC	Free, Prior and Informed Consent
GATT	General Agreement on Tariffs and Trade
GH2	Green Hydrogen Organisation
GHG	Greenhouse Gas
GHS	Green Hydrogen Standard (of the Green Hydrogen Organisation)
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GoO	Guarantee of Origin
GWP	Global Warming Potential
H_2	Hydrogen
H2U	Programa H2U (Uruguayan inter-institutional green hydrogen programme)
H2Uppp	International Hydrogen Ramp-Up Programme
HIF	Highly Innovative Fuels (HIF Global)
ICJ	International Court of Justice
IDB	Inter-American Development Bank
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change

IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
I-REC	International Renewable Energy Certificate
ISCC	International Sustainability and Carbon Certification
ISO	International Organization for Standardization
LAC	Latin America and the Caribbean
LATU	Laboratorio Tecnológico del Uruguay (Technological Laboratory of Uruguay)
LCA	Life-Cycle Assessment
MIEM	Ministerio de Industria, Energía y Minería (Ministry of Industry, Energy and Mining, Uruguay)
MTSS	Ministerio de Trabajo y Seguridad Social (Ministry of Labor and Social Security, Uruguay)
NDC	Nationally Determined Contribution
OAN	Observatorio Ambiental Nacional (National Environmental Observatory, Uruguay)
OJ	Official Journal of the European Union
OLADE	Organización Latinoamericana de Energía (Latin American Energy Organization)
OSH	Occupational Safety and Health
PEM	Proton Exchange Membrane
PNH2	Programa Nacional do Hidrogênio (Brazilian National Hydrogen Programme)
PoS	Proof of Sustainability
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PS	Performance Standard (of the International Finance Corporation)
PtX	Power-to-X
RCF	Recycled Carbon Fuel
RED II	Renewable Energy Directive II (Directive (EU) 2018/2001)
RED III	Renewable Energy Directive III (Directive (EU) 2023/2413)
RFNBO	Renewable Fuel of Non-Biological Origin
RSB	Roundtable on Sustainable Biomaterials

SBCH2	Sistema Brasileiro de Certificação do Hidrogênio (Brazilian Hydrogen Certification System)
SCER	Certificados de Energía Eléctrica de Fuente Primaria Renovable (Uruguay)
SDG	Sustainable Development Goal
SIN	Sistema Interconectado Nacional (national interconnected system, Uruguay)
SLO	Social License to Operate
SM-1 to SM-4	Safeguard Modules 1 to 4 (criteria areas of the Social Safeguards Module)
SSM	Social Safeguards Module
UNTS	United Nations Treaty Series
URSEA	Unidad Reguladora de Servicios de Energía y Agua (Uruguay)
UTE	Administración Nacional de Usinas y Trasmisiones Eléctricas (Uruguay)
VAL	Viabilidad Ambiental de Localización (Environmental Location Viability, Uruguay)
WTO	World Trade Organization

1. Introduction

1.1. Background & Problem

Against the backdrop of accelerating decarbonization efforts, renewable hydrogen has emerged as a strategically important energy carrier, particularly for sectors in which direct electrification is technically difficult or economically less feasible. The European Commission emphasizes renewable hydrogen's relevance for decarbonizing energy-intensive industries and transport, as well as for supporting the integration of renewable energy sources into the energy matrix.[1] At the same time however, the global hydrogen sector remains marked by considerable uncertainty: According to the International Energy Agency (IEA), the number and scale of low-emissions hydrogen projects have grown significantly in recent years, but market development remains uneven due to persistent challenges related to costs, infrastructure readiness and evolving regulatory frameworks.[2]

Hydrogen is not a uniform product and can be classified in different ways depending on its sustainability profile, most importantly according to its production pathway and the greenhouse gas (GHG) emissions associated with that method.[3] The most important variants are fossil-based, low-carbon and renewable hydrogen. Fossil-based hydrogen, or grey, brown, or black hydrogen, uses natural gas, brown coal or black coal respectively to produce hydrogen, resulting in significant CO_2 emissions.[4] A method to reduce these emissions is by combining the production from natural gas with Carbon Capture Utilization and Storage (CCUS), which is then considered low-carbon or blue hydrogen.[5] Renewable or green hydrogen is described by the European Commission as "[…] hydrogen produced through the process of electrolysis, using renewable electricity to split water into hydrogen and oxygen […]".[6]

Although the molecule itself is identical, its respective cost and emissions vary greatly, as summarized in Table 1.[7] In terms of cost, fossil-based production remains the most competitive. For the EU-27 in 2023, the levelized production cost of fossil-based (grey) hydrogen from steam methane reforming was around 3.20 €/kg, that of low-carbon (blue) hydrogen from autothermal reforming with carbon capture and storage around 3.80 €/kg, and

[1] Cf. European Commission (n.d.).
[2] Cf. IEA (2025a).
[3] Cf. Dulian/Erbach (2025).
[4] Cf. Dulian/Erbach (2025).
[5] Cf. Dulian/Erbach (2025).
[6] European Commission (n.d.).
[7] Cf. Ángel/Márquez (2022).

that of renewable (green) hydrogen from electrolysis with grid-mix electricity between 4.10 €/kg and 12.4 €/kg, at an average of about 7.90 €/kg.[8] In terms of emissions, measured on a comparable life-cycle basis that includes upstream and midstream emissions, unabated natural-gas hydrogen emits in the order of 10-14 kg CO_2-equivalent per kilogram of hydrogen, rising to as much as ~27 kg for the most upstream-intensive fossil routes, whereas combining natural gas with carbon capture lowers this to roughly 5-8 kg at moderate capture rates and below that at high capture rates.[9] Electrolytic hydrogen is emission-free at the point of production, so its production footprint is governed entirely by the electricity used: very low when powered by dedicated renewables, but rises towards the carbon intensity of the grid, where average grid-electricity is drawn.[10] This results in a segmentation of the market into different prices consumers are willing to pay for lower emissions.[11] While the difference in price may be one motivation for buying a certain "sort" of hydrogen, regulatory compliance and voluntary ambition to decrease GHG emissions trigger an increasing demand in renewable hydrogen.[12] As is the case for other products, green hydrogen requires a systematic identification and classification of its defining characteristics, in order to create a common base for its global trade.[13] One of the most important features examined is the respective hydrogen's GHG-emissions. For green hydrogen, the source of renewable electricity for its production through electrolysis is the main characteristic looked at when certifying.

[8] Levelized production costs (EU-27, 2023) as compiled in Dulian/Erbach (2025), section "Cost of fossil, low-carbon and renewable hydrogen" (underlying data: Hydrogen Europe, Clean Hydrogen Monitor 2024).
[9] Cf. IEA (2023), Executive Summary; corroborated by IEA (2024) (unabated natural gas 10–12 kg, unabated coal 22–26 kg CO_2-eq/kg H_2; electrolytic hydrogen emission-free at the point of production).
[10] Cf. IEA (2023), Executive Summary; IEA (2024).
[11] Cf. Ángel/Márquez (2022).
[12] Cf. International PtX Hub (2023).
[13] Cf. International PtX Hub (2023).

Table 1: Indicative production cost and life-cycle GHG emissions by hydrogen production pathway (own compilation)

TYPE (COLOUR)	PRODUCTION ROUTE	INDICATIVE PRODUCTION COST € / kg H_2	LIFE-CYCLE GHG EMISSIONS kg CO_2e / kg H_2
Grey fossil-based	Natural gas, steam methane reforming, no capture	**≈ 3.2**	**≈ 10 – 14**
Blue low-carbon	Natural gas + carbon capture (CCS / CCUS)	**≈ 3.8**	**≈ 5 – 8** lower at higher capture rates
Green renewable	Electrolysis with renewable electricity	**4.1 – 12.4** ▲ avg ≈ 7.9	**≈ 0** at production set by electricity source; near-zero with dedicated renewables
BAR SCALE		0 13	0 14

Various certification systems are already in place while more are conceptualized. Depending on the certification scheme, their respective methodology, referring to the scope of the value chain as well as the characteristics examined, may vary. Apart from GHG-emissions, additional sustainability criteria may be evaluated as well, such as, for example, the water and land use or the socio-economic impact of the production process.[14] As these criteria aren't visibly attached to the product, a consensually approved certification becomes necessary.[15] This serves to allow consumers to make an informed decision about what hydrogen to buy, as the properties are proven and accounted for.[16] For some markets, certification can also be a basic market access tool to make sure the imported products meet mandatory regulatory requirements.[17] As a result, participation in renewable hydrogen markets depends not only on the technical production, but also on the ability to demonstrate compliance with detailed regulatory criteria.

While the importance of social factors is widely acknowledged, existing certification frameworks emphasize technical and environmental criteria, particularly greenhouse gas accounting and renewable electricity sourcing, whereas social dimensions remain comparatively overlooked.[18] As a result, a gap emerges between the growing expectations that hydrogen projects contribute to broader sustainable development objectives and the comparatively limited integration of auditable social safeguards into currently relevant

[14] Cf. International PtX Hub (2023).
[15] Cf. International PtX Hub (2023).
[16] Cf. International PtX Hub (2023).
[17] Cf. International PtX Hub (2023).
[18] Cf. AHK Uruguay/GIZ H2Uppp (2025).

certification systems. This makes it especially important to examine how green hydrogen and derivatives projects may affect society, which can help establish a basis for future certification standards.[19]

With a share of 98 % of renewables in its electricity generation matrix, Uruguay presents very favorable conditions for the production of renewable hydrogen.[20] Uruguay's Green Hydrogen Roadmap, published in 2023, positions hydrogen as a key pillar in the transition towards a low-carbon economy.[21] In this context, the central challenge is no longer merely how hydrogen can be produced, but under which conditions it can be recognized as credible, compliant and marketable. This is especially relevant for countries such as Uruguay, which expresses an ambition to position itself as an exporter of hydrogen derivatives and whose hydrogen industry may depend on access to highly regulated international markets, such as the European Union.[22] Consequently, questions of certification, emissions accounting and regulatory alignment become central to the feasibility of hydrogen projects long before actual export volumes materialize.

In order to make Uruguay's fairly new hydrogen economy socially sustainable, more than climate neutrality alone is required.[23] Social considerations need to be integrated from the very beginning of project planning to identify and prevent possible adverse effects on local communities.[24] Regional initiatives such as CertHiLAC seek to incorporate broader sustainability dimensions, while also considering alignment with EU market-access requirements.[25] Consequently, an important analytical and practical gap exists regarding how Uruguay could implement a certification system that simultaneously supports EU RFNBO compatibility and integrates social safeguards adapted to its national context.

The thesis addresses this gap by examining the intersection of national hydrogen ambition and external regulatory conditionality. Rather than proposing a new certification standard, the thesis seeks to develop a conceptual pathway through which existing regulatory and certification approaches could be complemented by a Social Safeguards Module that strengthens both market credibility and social legitimacy in the development of Uruguay's

[19] Cf. AHK Uruguay/GIZ H2Uppp (2025).
[20] Cf. MIEM (2025b).
[21] Cf. MIEM (2023).
[22] Cf. MIEM (2023).
[23] Cf. AHK Uruguay/GIZ H2Uppp (2025).
[24] Cf. AHK Uruguay/GIZ H2Uppp (2025).
[25] Cf. Hartmann et al. (2023).

hydrogen economy. These two dimensions address distinct audiences: market credibility is owed primarily to the target export market, whose rules define eligibility, whereas social legitimacy is also owed to the producing context itself, the communities that host production but do not necessarily consume hydrogen. Whether these dimensions are best served by a single, EU-aligned certification or by complementing such a certification with a locally oriented layer is a question this thesis returns to in its comparative analysis and in the design of the pathway.

The thesis is structured into eight chapters. Following the introduction, Chapter 2 outlines the methodological approach. Chapter 3 presents the theoretical background relevant to renewable hydrogen certification, with particular attention to EU requirements as well as the regional certification scheme CertHiLAC. Chapter 4 then describes the hydrogen and certification landscape in Uruguay for further context. Chapter 5 contains the comparison between EU RFNBO requirements and CertHiLAC identifying regulatory and social gaps. Chapter 6 is dedicated to the development of the conceptual framework for integrating social criteria into an EU-compatible certification pathway before concluding the thesis, summarizing the main findings, discussing their implications and reflecting on the limitations.

1.2. Company profile

This thesis is situated in the institutional context of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The GIZ is organized as a limited liability company under German law (GmbH) and is entirely owned by the German Federal Government, with ownership exercised through the German Federal Ministry for Economic Cooperation and Development (BMZ).[26] The company operates worldwide in the field of international cooperation for sustainable development, combining political mandate, technical expertise and its international implementation capacity.[27]

Within Latin America and the Caribbean, GIZ is operating in 11 countries through local offices on topics such as renewable energy, governance, biodiversity and urban development.[28] Some of these offices are organizationally and administratively subordinate to regional offices.[29] The regional office of the “Southern Cone” is situated in Lima, Peru. Apart from implementation in Peru, since 2022 this office also constitutes the administrative center for

[26] Cf. GIZ (n.d. a).
[27] Cf. GIZ (n.d. a).
[28] Cf. GIZ (n.d. b).
[29] Cf. GIZ (n.d. b).

Argentina and Chile.[30] For the purpose of this thesis, GIZ Cono Sur can therefore be understood as the relevant regional operational environment in which cross-country energy and climate activities in the Southern Cone are coordinated. This is complemented by the regional office in Bolivia, responsible for administrative processes for implementation in Uruguay. The technical team however is located in Chile and managed by the Peru office.

A more specific thematic reference point for this thesis is the International Hydrogen Ramp-Up Programme (H2Uppp), a global programme which is implemented by GIZ on behalf of the German Federal Ministry for Economic Affairs and Energy (BMWE).[31] The H2Uppp programme is designed to promote the market ramp-up of green hydrogen in countries of the southern hemisphere through three central fields of action: the identification of business and project opportunities, the development of projects through public-private partnerships (PPPs) and further support for market readiness.[32] Within GIZ, the programme stands out, as it includes a high involvement and close cooperation with the private sector and serves as an example of how German development cooperation seeks to combine climate-policy, industrial transformation and private-sector engagement in the emerging hydrogen economy.

At a project level, this thesis is closely connected to the “Global Gateway Green Hydrogen Project in Uruguay” action. This action is jointly financed by the EU and Germany’s BMWE with the goal of promoting the green hydrogen market ramp up in Uruguay.[33] The European Union does so through its EUROCLIMA programme and under its Global Gateway strategy, while the implementation is the responsibility of BMWE’s H2Uppp programme.[34] The overarching goal is to contribute to carbon neutrality by 2050 both in Uruguay and the European Union, by promoting a sustainable green hydrogen economy.[35] An enabling environment is to be established for green hydrogen technologies and PtX applications for both domestic use as well as exportation.[36] Three areas of work of the action have therefore been established:

1. **Regulatory Development:** Strengthening the regulatory framework and risk mitigation strategies for the development of green hydrogen by supporting the formulation and

[30] Cf. GIZ (n.d. c).
[31] Cf. GIZ (2024); GIZ (2026a).
[32] Cf. GIZ (2024).
[33] CCf. GIZ (2026a).
[34] Cf. GIZ (2026a).
[35] Cf. GIZ (2026a).
[36] Cf. GIZ (2026a).

submission of recommendations to national authorities, while ensuring alignment and compatibility with the regulatory framework of the European Union.

2. **Infrastructure and Value Chains:** Designing efficient systems and infrastructure, developing value chains and integrating business models and opportunities that facilitate local and large-scale investment in green hydrogen.
3. **Social Impact and Local Development:** Ensuring equitable benefits and mitigation of potential negative effects by conducting social impact assessments and formulating measures, with particular emphasis on local value creation and the inclusive participation of relevant stakeholders.

The third pillar is looking to equip the decision-makers, the private sector and society as a whole with the capacity to design appropriate instruments and tools to maximize the benefits and minimize the negative impacts associated with the industry's development, by identifying social impacts.[37] This thesis is therefore closely related to this third pillar of work within the action.

1.3. Objective of the thesis

The objective of this thesis is to design a structured pathway for Uruguay to evidence EU RFNBO eligibility for renewable hydrogen (and selected derivatives) while integrating a lean, auditable Social Safeguards Module that complements technical compliance and strengthens legitimacy and offtake confidence.

To achieve this, the thesis will first outline the role and relevance of green hydrogen certification in the context of Uruguay's emerging hydrogen market. It will then provide a concise overview of the most relevant existing certification schemes before conducting a gap analysis of the two most pertinent frameworks – EU RFNBO rules and CertHiLAC – with a particular focus on social criteria and requirements. Having identified the most relevant challenges in social dimensions in Uruguay, the thesis will develop a practical proposal for how Uruguay could bridge identified gaps, in particular by defining an auditable "Social Safeguards" Module and outlining an implementation pathway that supports both EU market eligibility and socially responsible project development.

[37] Cf. GIZ (2026a).

1.4. Research questions

The main research question this thesis aims to answer is:

"How can Uruguay design and operationalize a certification pathway that is EU RFNBO-eligible while integrating a verifiable social safeguards layer suitable for green hydrogen projects?"

Derived from this, three sub-questions will also be examined in the course of this work:

1. What role and relevance does certification have in green hydrogen markets, specifically in Uruguay and what regulatory, sustainability and social requirements do EU-RFNBO-compliant mechanisms define?
2. How do existing green hydrogen certification approaches and governance structures available to Uruguay (e.g. CertHiLAC) align with and differ from these EU-RFNBO requirements, particularly regarding social aspects?
3. How can a certification pathway for Uruguay be designed to bridge identified gaps and operationalize EU-RFNBO compliance while ensuring credible and verifiable social safeguards for the most critical social risks in Uruguay?

1.5. Scope, Limitations and Assumptions

In the following, the scope and limitations applicable to this thesis are to be explained, as well as the respective assumptions outlined.

The thematic focus of this thesis lies in examining the role of certification systems as enabling mechanisms for market access and participation, particularly in relation to emerging international hydrogen value chains. In this context, special emphasis is placed on the regulatory relevance of certification for access to the European market and not to other potential markets, such as Asia. Second, the thesis will undertake a comparative analysis of the European Union's requirements for RFNBO and the regional certification scheme CertHiLAC. Third, it seeks to identify existing gaps in current certification approaches, especially with regard to socially and contextually relevant criteria that may not yet be sufficiently reflected in regulatory frameworks. These include aspects such as water use, land use, labor standards, social and gender inclusion, as well as the existence and accessibility of accompanying grievance mechanisms. Building on these findings, the thesis ultimately aims to develop a conceptual framework for the integration of social safeguards into a certification pathway that remains compatible with EU requirements while responding to local and regional sustainability concerns.

Geographically, the study focuses on Uruguay. The reason for this is the country's highly favorable renewable energy profile, its ambitions in the green hydrogen sector and growing relevance as a potential exporter to the European Union. Uruguay therefore constitutes a particularly suitable example for analyzing how international certification requirements interact with national sustainability considerations.

In terms of the product scope, the thesis focuses on renewable-based electrolytic hydrogen and selected derivatives, particularly e-methanol and e-fuels. These are especially relevant in the Uruguayan context because of high biogenic CO_2 availability and the close proximity of resources for production. These products are therefore increasingly discussed as future export commodities and contributors to the decarbonization of hard-to-abate sectors.

Several limitations apply to this thesis and should be acknowledged:

1. This thesis does not include field research, such as interviews, surveys or on-site assessments in Uruguay. As a result, findings rely on secondary sources and may not fully capture on-the-ground dynamics or stakeholder perceptions.
2. While the environmental and technical dimensions of sustainability may be acknowledged, they will not be analyzed in depth. The primary focus is deliberately placed on social dimensions.
3. The proposed certification pathway is not intended to be a fully implementable, operational system, but rather a conceptual model, highlighting design options and governance considerations.
4. Considering that both EU hydrogen regulation and Latin American certification initiatives are evolving, the analysis reflects the regulatory status at the time of writing and will therefore be susceptible to future changes.
5. Differences in institutional structures, enforcement capacity, and socio-economic contexts between the EU and Uruguay constrain the direct transferability of certification requirements.

The thesis rests on a small number of assumptions that frame its scope. First, and most importantly, it takes the large-scale, export-oriented project as its unit of reference, rather than smaller pilot-scale installations. This assumption follows from the thesis's own logic: EU RFNBO eligibility only becomes a decision-relevant condition where production is destined for export to a highly regulated market, and the social risks on which the thesis concentrates arise predominantly at scale. Second, it is assumed that Uruguay's hydrogen sector will develop substantially along this export-oriented trajectory toward the European market, consistent with

the direction set out in the national Green Hydrogen Roadmap and reflected in the current project pipeline. Third, the flagship projects surveyed in Chapter 4 are taken to be indicative of the social-risk profile that the sector will face as it scales and are used as reference cases rather than as a statistically representative sample.

2. Methodology

2.1. Research design overview

Methodologically, the thesis is based on a qualitative, document-based research design. This approach was selected as particularly suitable as the research focus lies on the analysis of regulatory frameworks, certification standards and general policy documents rather than the collection of primary quantitative data which in many cases might not be available yet. Since the thesis aims to analyze how social sustainability criteria are reflected in different certification schemes this design allows for an in-depth interpretation of normative requirements and context-specific governance structures.

Three interconnected methodological components are to be combined: a literature review, a comparative gap analysis and the more specific case study of Uruguay. The literature review aims to answer sub-question 1, by establishing the regulatory and conceptual foundations of green hydrogen certification with special emphasis on the EU framework and the regional certification system CertHiLAC. This step is essential for identifying key concepts, definitions and the sustainability criteria that shape the current certification landscape.

Building on this, the comparative gap analysis, based on sub-question 2, contrasts the points of convergence and divergence between the two certification frameworks, focused on social dimensions. A comparative approach is particularly appropriate here, since the interest lies not only in describing the two systems separately, but also in assessing the criteria addressed of one that might be absent in the other.

Finally, the case study of Uruguay serves the two remaining sub-questions rather than only the last. Sub-question 2 is itself framed nationally, so the Uruguayan material forms part of the object of the comparison and not merely its context; sub-question 3, concerning the design of the pathway, builds on its result.

2.2. Literature review

The first methodological component is a structured literature review, which provides the conceptual and regulatory foundation laid out mainly in Chapter 3 and the criteria subsequently

used in the comparative analysis. The review was conducted as a concept-centric process. This means that material was organized around the concepts that emerged from literature rather than around a sequential summary of individual publications.[38] The aim was to identify recurring concepts, such as chain of custody, Proof of Sustainability, RFNBO requirements, governance structures and centrally, the social sustainability dimensions of hydrogen production.

The search strategy combined several types of sources. Regulatory and legal sources were used to establish the binding requirements for RFNBO-eligibility. Institutional studies were central for the regional dimension and for CertHiLAC and are themselves comparative analyses of global certification systems benchmarked against the Latin American context. Standard-setter and NGO documents were used to capture sustainability and social criteria that are not yet codified in binding regulation, while peer-reviewed academic literature provided the conceptual grounding for the social dimension. Within this body of material, priority was given to scientific studies, books and peer-reviewed literature where available, while grey literature was used where it represented the most relevant or most current source, and was treated as such.

The inclusion logic was guided by relevance to the research questions, and the screening and synthesis of sources were documented in a literature review matrix maintained in spreadsheet form (see Annex). This matrix records, for each source, base data like its author(s), year, and title, alongside a summary of its content, a synthesis of its relevance, and the gaps or limitations identified. Searches were structured along a controlled vocabulary organized in four facets: an object facet ("hydrogen" OR "green hydrogen" OR "renewable hydrogen" OR "RFNBO" OR "Power-to-X" OR "derivatives" OR "e-fuels"), an instrument facet ("certification" OR "voluntary standard" OR "guarantee of origin" OR "chain of custody" OR "GHG accounting" OR "market access"), a dimension facet ("social sustainability" OR "social criteria" OR "energy justice" OR "social license to operate" OR "community engagement" OR "grievance mechanism" OR "land rights" OR "water" OR "labor standards" OR "governance"), and a contextual facet ("European Union" OR "RED III" OR "Latin America" OR "CertHiLAC" OR "Uruguay"). A typical combination therefore reads ("green hydrogen" OR RFNBO) AND certification AND ("social sustainability" OR "community engagement"). The same vocabulary was used to index the sources in the review matrix, so that the four social dimensions on which the comparison in Chapter 5 is built — water, land, labor, and community engagement —

[38] Cf. Webster/Watson (2002).

remain traceable to the body of literature from which they were derived rather than being imposed on it.

Searches were conducted in German, English and Spanish, since a substantial part of the regional material exists only in Spanish. They covered academic databases, the EU legal database EUR-Lex for regulatory texts, the publication repositories of the institutions active in the field, and the documentation published by the certification schemes themselves. The matrix records the core corpus screened in this manner; further material, in particular national legislation and project-level documentation on individual Uruguayan projects, was added case-specifically in Chapter 4 and does not form part of the systematic screening.

A substantial amount of the relevant evidence is grey literature produced by institutional or industry actors. This reliance reflects the nascent state of the field; the associated limitation was mitigated, though not eliminated, by prioritizing the most authoritative available sources and by triangulating across source types.

2.3. Comparative gap analysis

The second component is a comparative gap analysis between the EU RFNBO requirements and the regional certification system CertHiLAC. This method was chosen to evaluate how the different systems address the same underlying challenge and to bring out their respective advantages, disadvantages, and blind spots when set against each other. The analysis here draws on selecting a common problem, examining how each system responds to it, and then identifying and explaining the resulting similarities and differences. Applied to this thesis, the "function" of interest is the extent to which each framework defines and verifies the social sustainability conditions under which green hydrogen is produced and traded.

The pairing requires justification, since Uruguay has already signed the CertHiLAC Declaration and the choice of a regional system might appear settled. It is not. Signing commits Uruguay to a system that is not yet operational and that, lacking Commission recognition, confers no access to the Union Database and permits no Proof of Sustainability to be issued; a Uruguayan project exporting to the EU must therefore in practice certify under one of the recognized schemes, as Chapter 3.6.4 sets out. The two frameworks are consequently not competing options between which Uruguay must choose, but two layers that an Uruguayan export project would have to satisfy at the same time. The comparison accordingly asks what each of them requires of a producer in the social dimension, and what neither of them requires.

The comparison dimensions are for this reason not derived from either framework, which would privilege the categories of whichever system were taken as the baseline, but from the risk profile of the producing country. They are established in two stages: Chapter 3.4 derives four clusters of social dimensions from the IFC Performance Standards and the literature on hydrogen justice, and Chapter 4.4 tests each cluster against Uruguayan conditions and determines the country-specific form in which it is critical there. The comparison in Chapter 5 then proceeds along these calibrated dimensions in three steps. For each dimension it establishes, first, its normative status in each framework: mandatory, provided for as a reportable attribute, or absent, and second, whether any indicator, threshold, evidence requirement or audit protocol exists by which compliance could be verified. Third, it identifies the resulting convergences, divergences and gaps. Technical and environmental criteria are not compared in their own right, consistent with the scope limitation set out in Chapter 1 and are considered only where necessary to assess RFNBO eligibility.

Anchoring the criteria nationally has a methodological consequence that a framework-derived comparison could not produce. Because CertHiLAC's attribute set is calibrated to a regional risk average across Latin America and the Caribbean, a dimension may be present in the regional system and still fail to capture the form the corresponding risk takes in Uruguay. The design therefore allows gaps to be identified not only between the two frameworks but within CertHiLAC itself, measured against the requirements of a single member state — a result developed in Chapter 5.3.

2.4. Case-study approach

The third component embeds the comparative findings in a single case study of Uruguay. The case study is the appropriate design here, since the thesis asks how a certification pathway could be designed within a specific national context. Uruguay is examined as a means of understanding the broader phenomenon of how an emerging producer country can achieve EU RFNBO eligibility with credible social safeguards. In other words, the Uruguayan case serves as the vehicle through which the more general design problem is studied.

The selection of Uruguay is purposeful. According to Yin (2018) a single-case design is justified where the case is, among other possibilities, critical, unusual, common, revelatory or longitudinal.[39] Uruguay qualifies on two of these grounds in particular. It approximates a critical case for the question of social safeguards, because its electricity matrix is already almost

[39] Cf. Yin (2018), ch. 2.

entirely renewable, so that the technical and emissions-related hurdles to RFNBO eligibility are comparatively low and the decisive differentiator shifts towards the social and governance conditions of production. It is also a revelatory case, in that Uruguay's combination of strong export ambition towards the EU, early regional engagement through CertHiLAC, and the concrete institutional setting provides access to a constellation not yet widely documented. This is reinforced by scale. Uruguay is a small country whose domestic market cannot absorb production of the order the national Roadmap envisages; the Roadmap accordingly locates domestic demand in heavy transport and fertilizer production while assigning the export potential to methanol and to maritime and aviation fuels, as set out in Chapter 4.1. Production at scale is therefore export-bound by construction, and eligibility for a regulated import market is not one commercial option among several but the operative condition of the industry. The two features combine: the technical threshold is close to given, the external requirement is unavoidable, and what remains genuinely at issue is the social dimension. The aim here is depth and contextual integration for the design of the Social Safeguards module, not statistical generalization across countries.

The case study is not, however, purely downstream of the comparison. It enters the analysis twice: in Chapter 4.4, where the Uruguayan context calibrates the comparison dimensions before the comparison is carried out, and again after Chapter 5, where the identified gaps are translated into the design of the Social Safeguards Module. Methodologically, the case study integrates the outputs of the previous two components. It takes the gaps identified and interprets them against Uruguay's national policy, regulatory and institutional context in order to determine which of the identified social risks are most critical in the Uruguayan setting. On this basis, the case study translates the abstract comparison into a concrete proposal, namely the design of an auditable Social Safeguards module and an implementation pathway that supports both EU market eligibility and socially responsible project development. The case study operationalizes the findings and provides the bridge from analysis to the conceptual contribution of Chapter 6.

3. Theoretical background

3.1. Certification in green hydrogen/PtX markets

The market relevance of renewable hydrogen does not result from the physical characteristics of the molecule itself, but rather from the conditions under which it is produced. In this context, certification of decisive characteristics of renewable hydrogen and Power-to-X (PtX) becomes

necessary, as these are not visible in the final product. Certification therefore serves as a mechanism to make these product attributes transparent, comparable and verifiable for market participants.[40] Before examining what certification does, a conceptual distinction is to be made: “standards” describe a standardized way of doing things, while the term “certification” refers to providing a proof of adherence to or compliance with such standards.[41] Applied to hydrogen markets, this means that standards or regulatory frameworks define what qualifies as renewable or low-carbon hydrogen, while certification systems provide the mechanisms to credibly demonstrate that a specific product meets these criteria and upon compliance, issuing a certificate.

The need for such mechanisms comes from a fundamental market problem. Standards are crucial for the tracking and verification of product properties that may not be measurable.[42] This holds particularly true for the emerging global hydrogen and PtX market products, such as e-ammonia, e-methanol and synthetic fuels. Additionally, these markets are still characterized by uncertainty, fragmented regulatory approaches and evolving definitions.

Within a certification scheme, different attributes of the product may be certified with the most common one being the respective greenhouse gas intensity. That is, the quantity of greenhouse gases emitted per unit of product across a defined system boundary. It is commonly expressed in mass of carbon-dioxide equivalent per kilogram of hydrogen (kg CO_2eq/kg H_2) and, within the EU framework, per unit of energy content of the fuel (g CO_2eq/MJ), the two being interconvertible via the fuel’s lower heating value.[43] This is, however, not the only parameter relevant for measuring the characteristics of hydrogen and its derivatives. Other sustainability attributes may be applied to differentiate between a premium and non-premium product and may only be assigned to a product in a reliable way by means of commonly approved certification processes.[44]

The demand for these is driven by two different logics. First, regulatory compliance, where certification is used to prove that a product meets legally defined requirements. In these cases, certification may be necessary to count towards renewable energy targets, qualify for public support or even access a regulated market, such as the EU for example. Second, voluntary

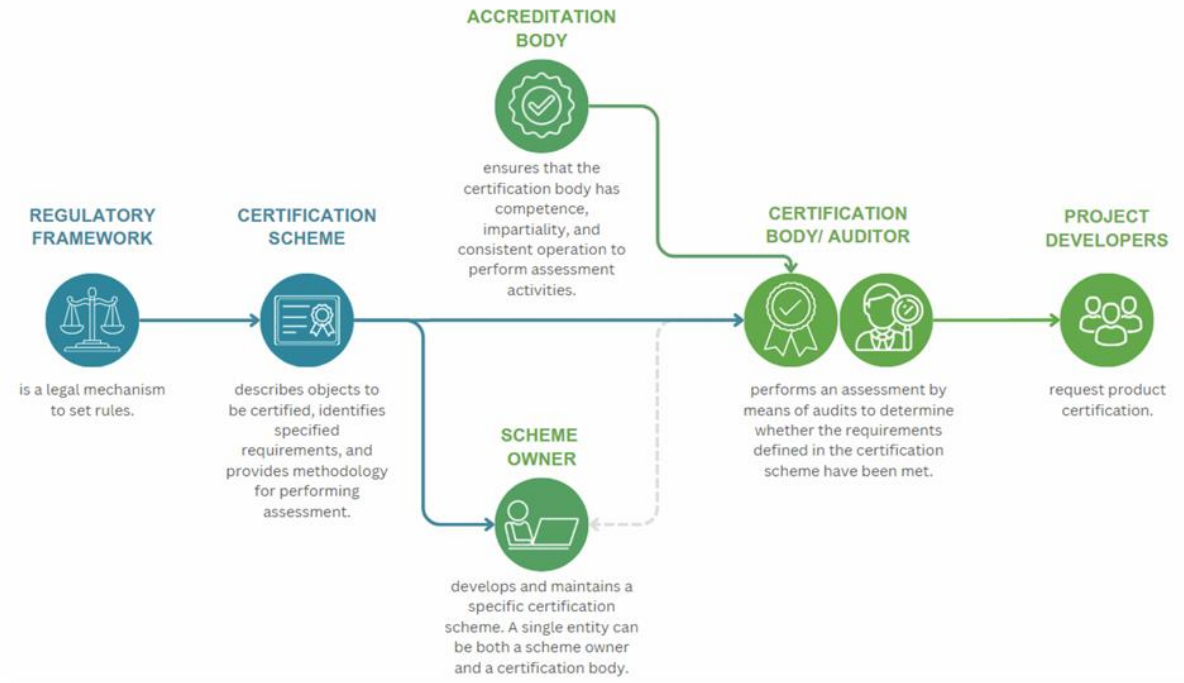
[40] Cf. International PtX Hub (2023).
[41] Cf. International PtX Hub (2023).
[42] Cf. International PtX Hub (2023).
[43] The EU emissions methodology for renewable fuels applies the GWP values fixed in Delegated Regulation (EU) 2020/1044, which are based on the IPCC Fifth Assessment Report (AR5).
[44] Cf. International PtX Hub (2023).

ambition: with large industrial producers aiming to decarbonize their supply chains, hydrogen and derivatives can play a crucial role.[45] Here, certification is used to communicate product characteristics, even where no binding legal obligation applies.[46] This voluntary dimension may be reflected in corporate sustainability reporting frameworks, support corporate climate strategies and the overall willingness to pay a premium for lower-emission products.[47]

In terms of how certification systems are structured, five core elements must be defined and implemented: the parameters and relevant data to be assessed, definitions to ensure comparability, governance and verification structures, qualification criteria for the assessed products, and tracking approaches to follow certified attributes through the supply chain.[48] Parameters and relevant data must be agreed upon in order to clarify which aspects of the certified product and the related product life cycle are considered relevant to be assessed and documented.[49] In order to ensure that the provided data actually refers to the same aspects and is therefore comparable, terms must be consistently defined, and system boundaries, methodological approaches for the calculation of parameters and other such aspects have to be clarified by common conventions.[50] The governance dimension deserves particular emphasis: clear governance structures assign responsibilities for the maintenance of the overall framework and requirements, ensure that all participants of the certification scheme adhere to the same common rules, and guarantee that these rules are properly maintained with evolving experience and scope.[51] Common rules for verification in turn ensure that the provided values and data are actually accurate and reliable, and that fraud is avoided.[52] The relation between these elements and their respective functions is illustrated in Figure 1.

[45] Cf. International PtX Hub (2023).
[46] Cf. International PtX Hub (2023).
[47] Cf. International PtX Hub (2023); Hartmann et al. (2023).
[48] Cf. International PtX Hub (2023).
[49] Cf. International PtX Hub (2023).
[50] Cf. International PtX Hub (2023).
[51] Cf. International PtX Hub (2023).
[52] Cf. International PtX Hub (2023).

Figure 4: Relation between key certification elements and their functions (Source: Tietze/Tsoumpa/Ullrich (2024), p. 8)



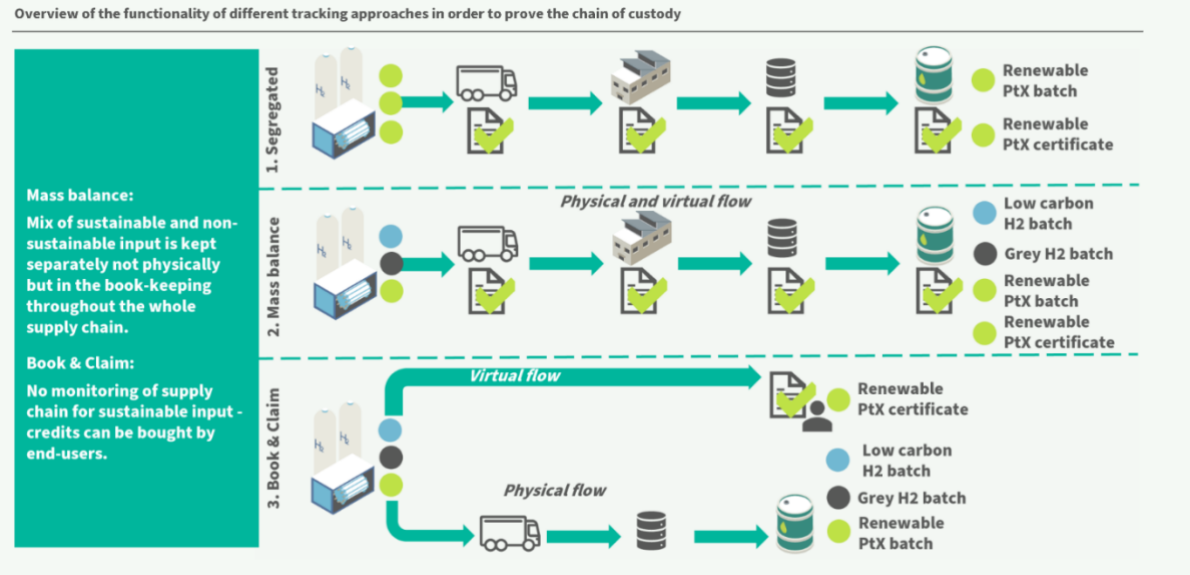
Different actors must play an active role in order to establish and facilitate such certification systems. These include governance institutions, referring to both governmental and private regulatory bodies, non-governmental scheme providers, technical system providers such as operators of tracking systems or databases, auditors who independently verify relevant information, and system users such as hydrogen producers, sellers and buyers.[53]

A central technical element within any certification system is how the attributes of a certified product are tracked along the supply chain, the so-called chain of custody. Here, two principal approaches have emerged as the most relevant for hydrogen and derivatives, both of which are illustrated in Figure 2. The mass balance approach allows for the physical mixing of certified and non-certified products, provided that the volumes of certified product are tracked and maintained in the bookkeeping throughout the whole supply chain.[54] This approach aims at ensuring a continuous traceability of a given quantity of a product in the supply chain.[55] The book and claim approach, by contrast, decouples the physical flow of the product from the accounting of the related production characteristics, allowing for certificates to be traded

[53] Cf. International PtX Hub (2023).
[54] Cf. Hartmann et al. (2023), p. 24; International PtX Hub (2023), p. 4.
[55] Cf. Hartmann et al. (2023), p. 24; International PtX Hub (2023), p. 4.

independently from the physical commodity.[56] This creates the option of a link between producer and consumer of a product with specific characteristics even when the physical supply chain makes direct delivery difficult or even impossible.[57]

Figure 5: Overview of the functionality of different tracking approaches in order to prove the chain of custody (Source: International PtX Hub (2023), p. 6)



There is also a distinction to be made between different certificate types. Guarantees of Origin (GoO) primarily serve disclosure purposes by providing information about the origin of a given quantity of renewable energy.[58] Proofs of Sustainability (PoS) on the other hand are more closely connected to compliance with sustainability and GHG emission-saving criteria.[59] For hydrogen and PtX products, this distinction matters because evidence of renewable electricity origin alone is generally not sufficient to demonstrate full compliance with more comprehensive regulatory requirements. Additional evidence may be required regarding emissions accounting, production timing, geographical correlation, traceability and verification.[60] The detailed EU requirements will be addressed separately in the later subchapter on the regulatory foundations of renewable hydrogen in the EU.

[56] Cf. International PtX Hub (2023).
[57] Cf. International PtX Hub (2023).
[58] Directive (EU) 2018/2001.
[59] Cf. International PtX Hub (2023).
[60] Cf. International PtX Hub (2023).

Despite growing importance, the current global certification landscape remains fragmented. Different standards on GHG emissions and additional sustainability requirements proliferate, in the EU and globally.[61] Regarding sustainability criteria more specifically, there is considerable variation in what existing certification schemes claim they will achieve, ranging from no additional sustainability rules to multi-criteria requirements across economic, environmental, social, and governance criteria.[62] These additional criteria are important to keep in mind from the outset, because while hydrogen projects are climate-oriented at the global level, they may still create local environmental or social impacts.[63] Tables 2a and 2b compare the voluntary certification schemes, distinguishing their regulatory standing (Table 2a) from their substantive requirements (Table 2b).

[61] Cf. International PtX Hub (2023).
[62] Cf. Goodwin et al. (2025).
[63] Cf. Hartmann et al. (2023).

Table 2a: Voluntary certification schemes for renewable hydrogen and PtX — regulatory standing (status: August 2026; own compilation based on the sources cited)

SCHEME Operator	EU RFNBO STATUS	PRODUCT SCOPE	ELIGIBLE ENERGY SOURCES
CertifHy Consortium initiated at the request of the EC	**Recognized** Impl. Decision (EU) 2024/3180, 19 Dec 2024	H_2 and derivatives (RFNBO scheme); separate, non-recognized GoO scheme for green and low-carbon H_2	RED-renewable electricity incl. hydro and geothermal; additionality, temporal and geographical correlation; nuclear not eligible
ISCC EU ISCC System GmbH	**Recognized** Impl. Decision (EU) 2024/3176, 19 Dec 2024	H_2 and derivatives, RCFs; also biofuels and forest biomass	RED-renewable electricity incl. hydro and geothermal; additionality and correlation; nuclear not eligible
REDcert-EU REDcert GmbH	**Recognized** Impl. Decision (EU) 2024/3194, 19 Dec 2024	H_2 and derivatives, RCFs; also biofuels	RED-renewable electricity incl. hydro and geothermal; additionality and correlation; nuclear not eligible
RSB Roundtable on Sustainable Biomaterials	**Certifying** since Nov 2025 on a positive technical assessment (RSB-STD-11-103 v1.0)	H_2 and derivatives, RCFs	RED-renewable electricity (wind, solar, geothermal, osmotic, ambient, tidal, wave, ocean, hydro); biogenic sources excluded
TÜV SÜD CMS 70 GreenHydrogen / GreenHydrogen+	**No EC recognition** private standard	Hydrogen	Renewable energy incl. biomass; waste, residues and by-products admissible — the broadest set in the comparison
TÜV Rheinland H2.21 P rivate standard	**No EC recognition** private standard	H_2 and derivatives	Non-biological renewable electricity (solar, wind, hydro, geothermal, ocean), aligned with the RFNBO delegated acts; electrolysis only
GH2 Green Hydrogen Standard 2.0 Green Hydrogen Organisation	**No EC recognition** global voluntary standard	H_2 and green ammonia; GHS 2.0 adds green methanol and synthetic methane	Near-100 % renewable (hydro, wind, solar, geothermal, tidal, wave, ocean); nuclear excluded; biomass only under additional sustainability criteria

Table 2b: Voluntary certification schemes for renewable hydrogen and PtX — requirements (status: August 2026; own compilation based on the sources cited)

SCHEME operator	GHG METHODOLOGY AND THRESHOLD	CHAIN OF CUSTODY	SOCIAL AND ADDITIONAL SUSTAINABILITY CRITERIA
CertifHy consortium initiated at the request of the EC	RED/RFNBO methodology (DR (EU) 2023/1185); **≥ 70 %** vs 94 gCO_2eq/MJ (≈ ≤ 3.4 kg $CO_2eq/kg\ H_2$). GoO route: ≥ 60 % vs 91 gCO_2eq/MJ, cradle-to-gate	Mass balance, Union Database; GoO route: book and claim	**None.** Confined to the RED criteria (GHG, electricity sourcing, traceability)
ISCC EU ISCC System GmbH	RED/RFNBO methodology; **≥ 70 %** vs 94 gCO_2eq/MJ	Mass balance, Union Database	**None within the RFNBO scope.** ISCC Principles 2–6 (human, labor and land rights) apply only to the agricultural biomass documents outside the RFNBO supply chain (Ch. 5.1)
REDcert-EU REDcert GmbH	RED/RFNBO methodology; **≥ 70 %** vs 94 gCO_2eq/MJ	Mass balance, Union Database	**None.** Requirements implement Delegated Regulations (EU) 2023/1184 and 2023/1185
RSB Roundtable on Sustainable Biomaterials	RED/RFNBO methodology; **≥ 70 %** vs 94 gCO_2eq/MJ	Mass balance or physical segregation	**Mandatory.** Electrolysis producers must demonstrate compliance with the RSB Principles and Criteria (12 principles incl. human and labor rights, rural and social development, food security, water, land rights)
TÜV SÜD CMS 70 GreenHydrogen / GreenHydrogen+	ISO 14040/14044 and RED Annex V/VI; comparator 80 or 94 gCO_2eq/MJ, **≥ 70 %**; cradle-to-gate ($GreenH_2$) or cradle-to-tank ($GreenH_2$+)	Book and claim ($GreenH_2$); mass balance ($GreenH_2$+)	**None.** No requirements on water or social aspects
TÜV Rheinland H2.21 private standard	RED GHG methodology; **≥ 70 %** vs 94 gCO_2eq/MJ; cradle-to-X (boundary defined by the applicant)	Not specified	**None.** No requirements on water or social aspects
GH2 Green Hydrogen Standard 2.0 Green Hydrogen Organisation	Well-to-gate per IPHE methodology; **≤ 1 kg $CO_2e/kg\ H_2$** (12-month average) — considerably stricter than the RFNBO threshold; green ammonia ≤ 0.3 kg $CO_2e/kg\ NH_3$	Project accreditation; tradable GH2 certificates of origin	**Mandatory ESG assessment.** Human rights, stakeholder and community consultation, obligatory social impact assessment with provisions for indigenous and vulnerable communities, SDG framing

Three patterns emerge from this comparison in Tables 2a and 2b. First, the schemes operating in the recognized RFNBO space (ISCC EU, CertifHy, REDcert-EU and, since November 2025, RSB) are technically harmonized: because they certify against the same Directive and its Delegated Acts, they converge on the same eligible electricity sources, the same emissions methodology, the same 70 % saving threshold and the same mass-balance logic, so that their differences lie less in criteria than in market reach, additional certification options and services.

Second, the schemes diverge on which further energy sources qualify and on the stringency of the threshold. Hydropower and geothermal energy are treated as renewable throughout; the genuine dividing lines are nuclear power, which no renewable or RFNBO scheme admits, and biomass and waste-derived energy, which TÜV SÜD CMS 70 permits, GH2 admits only under additional sustainability criteria and TÜV Rheinland excludes. The threshold varies markedly, from roughly 3.4 kg CO_2eq per kilogram of hydrogen under the RFNBO schemes to 1 kg under the GH2 standard. Third, and most consequentially for this thesis, the schemes divide on whether anything beyond greenhouse gas performance is certified at all. Within the recognized route, three of the four schemes confine themselves to the RED criteria in their RFNBO scope, while the RSB standard, certifying since November 2025, requires electrolysis producers to demonstrate compliance with the full RSB Principles and Criteria, including their social principles; outside the recognized route, GH2 makes an ESG assessment with obligatory social impact requirements a condition of accreditation. Social criteria are therefore neither mandated by the EU framework nor foreclosed by it: where they appear, they appear as scheme-level additions.

The fragmentation of certification systems creates practical challenges, especially for producer countries that seek to address multiple export markets simultaneously, each with its own certification requirements. At the same time, it opens space for regional initiatives – such as the Latin American CertHiLAC system later examined in this thesis – to design certification frameworks that reflect international market requirements and locally relevant sustainability dimensions.[64]

What emerges from this overview is that certification is not merely a technical exercise in emissions accounting. It is a governance instrument that shapes who can participate in green hydrogen markets, under what conditions, and at what cost. Understanding this dual character — at once a technical standard and a market access mechanism — is essential.

3.2. Relevance of certification

Having established what certification is and its basic working principles, this section turns to the question of why it matters – that is, the specific functions certification fulfils in practice and the concrete challenges it addresses in the emerging renewable hydrogen markets.

At an institutional level, certification can serve as an instrument of national climate governance. Despite a voluntary character in many contexts, a regional certification system

[64] Cf. Hartmann et al. (2023).

can function as a tool for verifying compliance with national standards and targets, offering a mechanism to account for hydrogen emissions through certificates, ensuring alignment with country-level goals, and with this, addressing the regional markets.[65] The inclusion of government representatives in certification governance is explicitly motivated by this consideration, aiming to ensure that the design of certification systems complements governmental decarbonization strategies and policies and aligns with national emissions databases.[66] The certification system can thereby contribute to the tracking and monitoring of emissions reduction commitments, for example in accordance with a country's respective Nationally Determined Contribution (NDC).[67]

Certification also fulfils a direct commercial function by providing a common supporting basis for off-take contracting and project financing. The absence of clear, standardized product documentation has concrete consequences, as using color-based labels or qualifiers to describe hydrogen — such as "blue" or "green" hydrogen — potentially conceals diverse emission intensities and has proven impractical as a foundation for making contracting or financing decisions, thereby deterring potential investors.[68] Reporting emission intensity transparently promotes flexibility in accommodating various production technologies, allows for easier comparison by standardized units and scopes of measurements/methodologies, and preserves compatibility with future regulatory requirements.[69] For lenders and off-takers, certified and attribute-specific product documentation provides the information needed to assess project quality, structure long-term purchase agreements, and meet due diligence requirements — all prerequisites for bankable project structures.[70] The absence of bankable off-take propositions has been explicitly identified as a factor contributing to the perception of green hydrogen projects as risky and impeding the attraction of adequate investment at scale.[71]

A structurally critical function of certification lies in its role as a safeguard against the making of misleading or unsubstantiated claims about the environmental properties of the product.[72] Since the molecule itself carries no visible indicator of its production pathway, without

[65] Cf. Hartmann et al. (2023), p. 9.
[66] Cf. Hartmann et al. (2023), p. 10.
[67] Cf. Hartmann et al. (2023), p. 34.
[68] Cf. Hartmann et al. (2023), p. 8.
[69] Cf. Hartmann et al. (2023), pp. 8 and 16.
[70] Cf. Bird & Bird (2026).
[71] Cf. UNIDO (2024).
[72] Cf. EBA (2024).

certification there is no reliable mechanism to distinguish a genuinely low-emission product from one produced through conventional, carbon-intensive means.[73] This risks distorting markets by misdirecting investments towards actors with unverified sustainability credentials, undermining the credibility of genuine sustainability efforts.[74] Applied to hydrogen specifically, credible quality infrastructure and a transparent chain of custody are necessary to build confidence and trust in hydrogen certificates, and existing hydrogen certification systems have been identified as presenting gaps in design and standardization that remain to be addressed before they can be considered fully suitable for cross-border trade.[75]

The structurally most important function of certification is, ultimately, its role as a direct prerequisite for market participation. As hydrogen demand increases in importing regions and trade begins to emerge between countries with competitive renewable energy advantages and those seeking to decarbonize their industrial base, an internationally recognized certification system becomes necessary to identify the various forms of hydrogen, their associated carbon footprints, and other sustainability criteria in a way that is actionable for buyers and regulators alike.[76] For producer countries seeking to access major demand markets, certification is not a voluntary enhancement — it may be the condition of entry.[77] When the environmental and social requirements of projects align with those of financial institutions or multilateral organizations, certification can additionally enhance financing possibilities for projects in the region.[78]

A further reason why certification matters is one of timing. Because the greenhouse gas intensity of hydrogen, and therefore its eligibility under a target market's threshold, is largely determined by the design of the production process and the way its electricity is sourced, certification requirements are most usefully addressed at an early stage of project development rather than once a plant has been built. Where a planned configuration would exceed the emissions threshold of the intended export market, the design may need to be re-evaluated, an adjustment that is considerably more costly if identified late.[79] In response, an advisory practice of pre-certification assessment has emerged, in which specialized consultancies, and the recognized schemes themselves, evaluate a project against the

[73] Cf. International PtX Hub (2023), p. 1.
[74] Cf. EBA (2024).
[75] Cf. IRENA/RMI (2023).
[76] Cf. IRENA/RMI (2023).
[77] Cf. Energy Partnerships (2024).
[78] Cf. Hartmann et al. (2023), p. 9.
[79] Cf. International PtX Hub (2026).

applicable criteria before commercial production begins. This is particularly relevant for producers in exporting countries, where EU rules do not always map neatly onto the local electricity-market design, and has already been applied to hydrogen and ammonia projects across Latin America.[80]

Taken together, these dimensions illustrate that certification is not a peripheral compliance exercise but a foundational enabling condition for the development of renewable hydrogen markets. It determines market access, shapes financing conditions, guards against integrity failures, supports commercial contracting, and links private sector activity to public climate goals. The design and implementation of a credible, internationally compatible certification system is therefore, especially for emerging producer countries such as Uruguay, not merely a regulatory formality but a strategic prerequisite for translating renewable energy potential into viable hydrogen export activity.

3.3. Sustainability in certification

At the most fundamental level, all existing hydrogen certification systems share a common baseline, which is the measurement and documentation of greenhouse gas emissions intensity. The primary energy source, basic production plant information and the intensity and scope of GHG measurement are the attributes present in every certification system worldwide.[81] The climate value of these products depends on the degree of emissions reduction compared with fossil alternatives.[82]

GHG intensity alone does not constitute a complete picture of a production project's sustainability. The broader concept of sustainability in certification encompasses environmental, social, and economic dimensions that extend well beyond the carbon accounting of the production process itself. Accordingly, GHG intensity is not the only parameter relevant for measuring the characteristics of hydrogen and derivatives: other sustainability criteria, such as the water and land use or the socio-economic impact in the producing country, are increasingly likely to be applied to differentiate between premium and non-premium products in international markets.[83] These additional sustainability criteria share a critical property: unlike GHG emissions, which can be calculated from process data, they

[80] Cf. International PtX Hub (2026).
[81] Cf. Hartmann et al. (2023), p. 17.
[82] Cf. IRENA/RMI (2023), p. 8.
[83] Cf. International PtX Hub (2023), p. 1.

cannot be derived from the physical product at all – making certification the only mechanism through which they can be reliably assigned to a traded volume of hydrogen.[84]

These additional sustainability factors span both environmental and social domains, but the two are closely intertwined rather than cleanly separable: many of the challenges associated with large-scale hydrogen production register at once as ecological and as human or social impacts. Two resources on which such projects draw heavily are water and land. Water use is simultaneously an environmental burden — freshwater depletion and, at water-scarce sites, local scarcity — and a social one, as industrial demand competes with agricultural and community uses. Land use likewise carries ecological consequences for biodiversity and habitat alongside social consequences for neighboring and indigenous communities. Pollution pathways behave the same way: brine disposal from the desalination plants that supply electrolysis affects marine ecosystems and the health of nearby populations alike. This coupling is embedded in life-cycle assessment itself, where environmental burdens such as toxicity and particulate matter are characterized not only as damage to ecosystem quality but also, through a dedicated endpoint category, as damage to human health.[85] Social life-cycle assessment was developed on the same understanding, complementing rather than replacing environmental assessment and commonly applied in combination with it.[86]

A degree of structuring nonetheless aids understanding. Grouping the more distinctly social attributes separately from the primarily biophysical ones provides a useful organizing device, so long as it is treated as a lens rather than a firm boundary. It is on this basis and drawing on a comprehensive analysis of hydrogen certification systems worldwide assessed against the specific social, economic and environmental context of the producing region, that this thesis foregrounds the social dimension while recognizing that it cannot be fully disentangled from the environmental one.

These additional attributes also raise a question of measurement that the climate criterion has, in effect, already resolved. Greenhouse gas intensity is reported as a standardized quantity per unit of product, that is, normalized to a functional unit: the quantified function of the system that serves as the reference to which all inputs and outputs are related, and against which

[84] Cf. International PtX Hub (2023), p. 1.
[85] On the characterisation of environmental burdens as damage to human health as well as to ecosystem quality cf. Wu/Su (2020).
[86] On social life-cycle assessment as a complement to, and applied in combination with, environmental LCA cf. Su (2020), ch. 7, drawing on the UNEP/SETAC Guidelines for Social Life Cycle Assessment of Products (Benoît et al., 2009).

alternatives fulfilling the same function can be compared.[87] Life-cycle assessment (LCA) provides the broader methodological framework for extending this logic to other topics, expressing them per functional unit across a range of impact categories beyond climate change, for example water use (addressed by a dedicated water-footprint standard), eutrophication from nutrient release (expressed, for instance, in nitrogen- or phosphorus-equivalents), acidification, and human and ecological toxicity, each measured through its own characterization indicator.[88] Not all sustainability attributes lend themselves equally to this treatment, however: while most environmental burdens can in principle be normalized to a functional unit, several social attributes cannot. As they cannot be referred to a per-unit metric, they must be assessed qualitatively instead, a limitation that social life-cycle assessment only partially addresses.[89] This uneven measurability helps explain why the climate criterion has been the first to be translated into binding, quantitative thresholds, while the remaining sustainability dimensions are still largely addressed descriptively.

How these dimensions are reflected in certification schemes varies considerably. While GHG criteria have been codified into binding regulatory requirements in key markets — most prominently in the EU's framework for renewable hydrogen — additional sustainability criteria remain largely absent from mandatory regulatory requirements and are instead addressed through voluntary certification schemes or regional frameworks.[90] This asymmetry has consequences: certification schemes that focus exclusively on GHG thresholds can satisfy regulatory market access requirements while remaining silent on water use, community impacts, or labor conditions in the producing country. The variation in what existing certification schemes claim to achieve ranges from no additional sustainability rules to multi-criteria requirements spanning economic, environmental, social and governance dimensions.[91] This divergence in scope and ambition is one of the defining characteristics of the current, fragmented global certification landscape.

The significance of this gap becomes particularly apparent in the context of producing countries in the Global South, where large-scale hydrogen production at sites with ample renewable energy frequently intersects with water-scarce environments, ecologically sensitive land, and communities with limited formal political representation. Against this backdrop,

[87] Cf. Su (2020), ch. 7.
[88] Cf. Wu/Su (2020), Table 3.1.
[89] Cf. Su (2020), ch. 7.
[90] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), pp. 149 and 151.
[91] Cf. Hartmann et al. (2023), p. 16.

additional sustainability criteria are not merely a market differentiation tool — they are a governance mechanism for ensuring that the expansion of hydrogen export industries does not reproduce patterns of extractive development. The extent to which certification systems incorporate and credibly verify such criteria therefore has direct implications for the kind of development trajectory that hydrogen can support in producing regions. These dynamics, and their specific institutional expression in social sustainability provisions, will be examined in depth in the following subchapter.

3.4. Social Sustainability in Hydrogen Certification

Certification systems vary substantially in the sustainability dimensions they cover, and the variation ranges from exclusive GHG accounting to multi-criteria frameworks encompassing environmental, social and governance dimensions. This chapter intends to deepen this analysis by examining what social sustainability means in the context of large-scale hydrogen project development, why it matters for certification systems specifically, and why it remains structurally underdeveloped in current frameworks.

Dillman and Heinonen (2022) argue that the emerging hydrogen economy must be evaluated not only through a climate lens but through a distributive, recognition, and procedural justice lens, examining how benefits and burdens are shared, whose interests are acknowledged in decision-making processes, and whether those affected by projects have meaningful opportunities to participate in decisions that concern them.[92]

For the purpose of this thesis, social sustainability in the context of hydrogen certification refers specifically to those social risk and impact dimensions that are verifiable, attributable to a given production project, and therefore suited for integration into a certification framework.

A central conceptual tool for understanding the social dimension of energy project development is the Social License to Operate (SLO), defined as the level of approval or acceptance that an industry, organization, or project earns from communities and other stakeholders.[93] It is distinct from a formal legal permit, as the SLO reflects the degree to which a project is perceived as legitimate and trustworthy by the communities that host it. This approval must be earned and maintained, as its absence can have concrete consequences.[94] The concept is not uncontested, however. Because the word “license” connotes a formal authorization issued by a defined authority, several scholars and public-sector actors regard it

[92] Cf. Dillman/Heinonen (2022).
[93] Cf. Mpinga/Klenke (2025), p. 6.
[94] Cf. Mpinga/Klenke (2025), p. 8.

as a misnomer. It describes an informal, negotiated and continuously renewed acceptance rather than any conferred right, and its looseness has been criticized for allowing the term to be invoked by proponents to signal legal legitimacy while blurring the boundary with the formal regulatory authorization that only the state can grant.[95] This thesis therefore employs the SLO not as a literal license but as an analytical lens, retained for the attention it directs to community acceptance as a material condition of project development.

The World Bank's ESMAP report on SLO in renewable energy projects, addressing lessons for the hydrogen sector, identifies the securing of social acceptance as directly shaping project bankability, investment readiness, and long-term project sustainability, framing it not as a peripheral social concern but as a core condition for the financial viability of clean hydrogen projects.[96] For clean hydrogen specifically, trust, built through early, proactive, and transparent engagement and grounded in a commitment to generate shared socioeconomic value for host communities beyond mere harm avoidance, is identified as the foundational currency of the SLO.[97]

The Roundtable on Sustainable Biomaterials (RSB), for instance, organizes its standard around twelve principles that reach well beyond the mandated core of greenhouse-gas performance.[98] Covering water, soil, air, conservation, local food security and land rights, together with human and labor rights and rural and social development.[99] Comprehensive schemes such as ISCC likewise extend certification beyond the mandated core. It is, however, precisely because these protections sit on the voluntary side, adopted at the discretion of a producer or scheme rather than required for market access, that they have not been consolidated into the criteria governing eligibility.

The social dimensions most analytically relevant to renewable hydrogen production projects can be organized into four clusters, drawing on the IFC Performance Standards, the internationally recognized benchmark framework for environmental and social risk management in large-scale development projects, covering assessment and management of environmental and social risks and impacts (PS1), labor and working conditions (PS2),

[95] On the contested status of the term cf. Owen/Kemp (2013) (arguing that the concept is analytically unworkable and can be used by industry to manage or mask opposition); on the tension between informal social acceptance and formal regulatory authorisation cf. Gehman et al. (2017).
[96] Cf. World Bank (2025b).
[97] Cf. Mpinga/Klenke (2025), p. 8.
[98] Cf. RSB (2023) – twelve principles spanning legal (Principles 1 and 12), social (4, 5 and 6), environmental (3, 7, 8, 9 and 10) and management (2 and 11) practice.
[99] Cf. RSB (2023).

resource efficiency and pollution prevention (PS3), land acquisition and involuntary resettlement (PS5), and indigenous peoples (PS7).[100] The four clusters, which structure the calibration to the Uruguayan context in Chapter 4.4 and the comparison in Chapter 5, are defined as follows:

Water use and access: Electrolytic hydrogen production is water-intensive, with significant consumption associated with the electrolysis process, cooling, and where applicable desalination and brine disposal.[101] Where production sites are located in water-scarce regions, industrial water demand intersects with local agricultural, ecological, and domestic consumption needs, creating sustainability risks. IFC PS3 requires project developers to assess and manage water-related impacts.[102] Sources, sustainable use of water, and wastewater treatment have been identified as LAC-specific attributes, because of the regional water stress context.[103]

Land use and land rights: Large-scale renewable hydrogen production requires extensive land areas for electricity generation infrastructure. IFC PS5 requires developers to avoid involuntary displacement wherever possible and to ensure fair compensation and community participation where it cannot be avoided.[104] PS7 requires Free, Prior, and Informed Consent (FPIC) for projects affecting indigenous communities' lands or livelihoods, in defined circumstances. Land use conflicts have been identified as among the most common sources of project-level social risk in the clean hydrogen sector.[105]

Labor standards and decent work: Large-scale hydrogen and derivatives projects generate significant employment, but its distribution over the project lifecycle is uneven: the construction of plants, dedicated generation parks and infrastructure creates large volumes of temporary employment, whereas the operating phase requires comparatively few, more technically demanding permanent positions.[106] The ILO defines green jobs as "decent jobs that contribute to preserve or restore the environment", and for hydrogen these jobs largely draw on existing occupations that require hydrogen-specific upskilling and reskilling.[107] Employment generation therefore does not automatically translate into social value: the quality, safety, durability,

[100] Cf. IFC (2012).
[101] Cf. Mpinga/Klenke (2025), p. 40.
[102] Cf. IFC (2012).
[103] Cf. Hartmann et al. (2023), p. 17.
[104] Cf. IFC (2012).
[105] Cf. Mpinga/Klenke (2025), pp. 40–43.
[106] Cf. ILO (2025), p. 3.
[107] ILO (2016).

inclusiveness and local content of the jobs matter substantially. PS2 requires fair treatment, non-discrimination, protection of collective bargaining rights, and safe working conditions.[108]

Community engagement, transparency, and grievance mechanisms: The procedural dimension of social sustainability concerns the conditions under which communities are informed about, consulted on, and able to meaningfully influence project decisions, including the design of consultation processes, the quality of information provided, and the existence of accessible grievance mechanisms through which affected parties can raise concerns and seek remedy without fear of retaliation. IFC PS1 specifies each of these elements as a requirement of stakeholder engagement: the disclosure of relevant project information to affected communities (para. 29); a documented consultation process that begins early, rests on the prior disclosure of meaningful and accessible information and is free of manipulation, coercion or intimidation (para. 30); informed consultation and participation for projects with potentially significant adverse impacts, under which the operator incorporates community views into its decisions and informs those affected how their concerns have been considered (para. 31); and a grievance mechanism that is readily accessible, at no cost and without retribution to the complainant (para. 35).[109] Meaningful engagement begins well before the actual land acquisition and is to be maintained across the full project lifecycle, which PS1 mirrors by framing stakeholder engagement as an ongoing process accompanied by periodic reporting to affected communities.[110] [111]

Notwithstanding the relevance of the dimensions outlined above, social sustainability criteria are absent from the EU RFNBO framework and from most of the certification schemes compared in Tables 2a and 2b; where they exist, as in the RSB and GH2 standards, they remain scheme-level additions rather than conditions of market access. Empirical research on the voluntary schemes recognized under the Renewable Energy Directive, so far mainly for biofuels, indicates that competition among schemes can create downward pressure on the stringency of social requirements, because producers may opt for the least demanding scheme, whereas schemes with civil-society organizations in their governance tend to apply more stringent social criteria.[112] For a certification pathway, this dynamic is a design risk to be actively mitigated rather than a reason to forgo voluntary certification as a mechanism.

[108] Cf. IFC (2012).
[109] Cf. IFC (2012), PS1, paras. 29–31 and 35.
[110] Cf. Mpinga/Klenke (2025), p. 8.
[111] Cf. IFC (2012), PS1, paras. 25 and 36.
[112] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), p. 151.

The structural underdevelopment of social sustainability in certification carries particular consequences in the Southern Hemisphere. The emerging hydrogen economy's logic is built on geographical specialization, with countries that hold optimal renewable resources positioned as large-scale exporters to high-demand markets in Europe. The scale of land, water, and social resources that this transformation entails are significant.

For producing countries, certification frameworks confined to GHG accounting present a structural asymmetry: the climate benefits of renewable hydrogen accrue globally, while social costs could be generated locally, by communities that frequently have limited institutional capacity to assert their interests in global supply chain governance. Certification systems that do not credibly verify the social conditions of hydrogen production risk allowing supply chains to proceed without adequately addressing local social costs, even as they contribute to global climate objectives. This underscores the need for social safeguards that are as rigorous as the GHG accounting requirements already in place. Such safeguards are therefore not peripheral to the technical compliance discussion; the demand for them also reflects the recognition that social and planetary dimensions are interdependent.[113] This framing, and the analytical dimensions it comprises, constitutes the lens through which the EU RFNBO regulatory framework and the CertHiLAC regional certification system are subsequently examined.

3.5. Regulatory foundations of renewable hydrogen in the EU

3.5.1. Evolution of the EU framework

This subchapter intends to ground the previous discussion of certification in the framework most consequential for this thesis, the European Union's regulatory regime for renewable hydrogen. For this, a term has to be clarified first. So far, the thesis has referred to "renewable hydrogen", a description of the origin of the energy used as well as the technology (electrolysis) to produce the molecule. EU law, however, does not regulate hydrogen under that name. It regulates it under the broader category of Renewable Fuel of Non-Biological Origin (RFNBO), which Article 2 (36) of the Renewable Energy Directive defines as "liquid and gaseous fuels the energy content of which is derived from renewable sources other than biomass".[114] Hydrogen produced through electrolysis from renewable electricity is therefore

[113] Cf. Stockholm Resilience Centre (n.d.).
[114] Directive (EU) 2023/2413.

the archetypal RFNBO, the category itself however also encompasses hydrogen derivatives such as renewable ammonia and synthetic fuels.

The EU's handling of renewable hydrogen is not a self-standing regime, but a layer built onto the successive updates of the Renewable Energy Directive. The first Renewable Energy Directive (RED I, Directive 2009/28/EC) introduced the initial binding renewable energy target and the first sustainability criteria for biofuels, but did not yet address hydrogen production from renewable electricity.[115] The concept of a "renewable fuel of non-biological origin" entered EU law with the recast Directive (RED II, Directive 2018/2001), which defined RFNBOs, required that their greenhouse gas emissions savings amount to at least 70 % from the 1 January 2021, established the framework for guarantees of origin, and empowered the Commission to adopt delegated acts specifying both the conditions under which the electricity used may be counted as fully renewable and the methodology for calculating emissions savings.[116]

The Commission exercised that mandate through two Delegated Regulations adopted on the 10 February 2023.[117] Commission Delegated Regulation (EU) 2023/1184 (Delegated Act I, the "Additionality" or renewable-electricity act) defines when the electricity input qualifies as fully renewable while Commission Delegated Regulation (EU) 2023/1185 (Delegated Act II) sets the life-cycle methodology for the 70 % emissions-savings threshold.[118] The procedural counterpart lies in Commission Implementing Regulation (EU) 2022/996, which governs the verification of sustainability and emissions criteria, the recognition of certification schemes, as well as the content of the Proof of Sustainability.[119] Together, these instruments operationalize the abstract requirements into auditable obligations.

The framework was then substantially revised by Directive (EU) 2023/2413 (RED III), which entered into force on the 20 November 2023 with a transposition deadline for Member States of 21 May 2025.[120] Transposition has proceeded slowly and unevenly. Only Denmark met the deadline, and in July 2025 the Commission opened infringement proceedings against 26 Member States for failing to communicate complete transposition.[121] By 2026 only a handful had transposed the directive. Germany was initially among the delayed states but has since

[115] Directive 2009/28/EC.
[116] Directive (EU) 2018/2001.
[117] Delegated Regulation (EU) 2023/1184; Delegated Regulation (EU) 2023/1185.
[118] Delegated Regulation (EU) 2023/1184; Delegated Regulation (EU) 2023/1185, both OJ L 157, 20.6.2023.
[119] Implementing Regulation (EU) 2022/996.
[120] Directive (EU) 2023/2413.
[121] On the transposition status cf. European Commission (2025).

legislated the core of RED III into national law, with the Bundestag adopting on 24 April 2026 the Second Act to Further Develop the Greenhouse Gas Reduction Quota, which amends the Federal Emissions Control Act (BImSchG) to transpose the directive's transport and RFNBO provisions.[122]

For the purpose of this thesis, three changes are particularly important. First, RED III broadened the scope of the RFNBO definition, whereas RED II had confined the definition to *transport* fuels of non-biological origin, Article 2 (36) was replaced, dropping that restriction and extending it to renewable fuels used in any sector.[123] Second, RED III raised the binding renewable-energy target to at least 42.5 % by 2030 and introduced sectoral RFNBO targets: under Article 22a, at least 42 % of the hydrogen used for final energy and non-energy purposes in industry must be RFNBO by 2030, rising to 60 % by 2035, subject to limited flexibility under Article 22b; and under Article 25, RFNBOs must account for at least 1 % RFNBO within the combined 5.5 % sub-target for advanced biofuels and RFNBOs in transport by 2030.[124] Third, RED III inserted a dedicated greenhouse gas criterion for RFNBOs in in Article 29a, confirming that RFNBO energy may only be counted towards the Directive's targets where emissions savings reach 70 %. In addition, Article 31a expanded the Union Database beyond transport so that it can trace renewable fuels and their life-cycle emissions across sectors.[125]

Because the delegated acts were adopted under RED II, but continue to apply after RED III, with technical terms subsequently aligned to the revised Directive by Commission Delegated Regulation (EU) 2024/1408, the analysis references whichever instrument is currently applicable, and flags where RED III has superseded or renumbered a RED II provision.[126]

Important for this thesis furthermore is Article 1 of the Delegated Regulation (EU) 2023/1184, which provides that its rules apply irrespective of whether the RFNBO is produced inside or outside the territory of the Union.[127] The eligibility requirements set out below are therefore not internal EU rules from which a third-country producer such as Uruguay is exempt, but precisely the conditions that Uruguayan hydrogen must satisfy in order to be marketable as an RFNBO in the EU.

[122] Develop the Greenhouse Gas Reduction Quota by the Bundestag on 24 April 2026).
[123] Directive (EU) 2023/2413.
[124] Directive (EU) 2023/2413.
[125] Directive (EU) 2023/2413.
[126] Delegated Regulation (EU) 2024/1408.
[127] Delegated Regulation (EU) 2023/1184, Art. 1.

3.5.2. RFNBO eligibility

To be placed on the EU market as RFNBO and counted towards the Directive's targets, hydrogen must satisfy four cumulative requirements: it must fall within the RFNBO definition, be produced from electricity that qualifies as fully renewable, achieve at least a 70 % life-cycle greenhouse gas emissions savings, and must be traceable throughout the supply chain.[128] These requirements are narrower than the sustainability criteria the Directive imposes on biofuels, bioliquids and biomass fuels, whose feedstock must additionally satisfy the land-use restrictions of Article 29(3)–(5), which bar land of high biodiversity value, high carbon stock, or peatland.[129] Because RFNBO hydrogen is not produced from biomass, it is not itself subject to these criteria; they can, however, re-enter the pathway where a derivative is synthesized with biogenic CO_2. As the overall definition has already been addressed, the remaining three criteria are examined here in detail.

The renewable character of an RFNBO produced by electrolysis is determined entirely by the electricity used. Delegated Regulation (EU) 2023/1184 recognizes three sourcing routes: a direct physical connection between the electrolyzer and a renewable installation, a grid connection combined with one or more renewables power purchase agreements (PPAs), and, in defined circumstances, electricity drawn from the grid without a PPA.[130] Where electricity is taken from the grid through a PPA, it may only be counted as fully renewable if it meets the criteria of additionality, temporal, and geographical correlation.[131] The purpose of these criteria is to ensure that hydrogen production is met by newly added renewable capacity, generated when and where renewable electricity is actually available, so that it does not simply divert existing renewable power and thereby induce additional fossil generation elsewhere in the system.[132]

Additionality requires that the renewable electricity comes from installations that are, in substance, new. An installation qualifies as new, if it came into operation no earlier than 36 months before the electrolyzer, and it must generally not have received operating or investment aid.[133] Electrolyzers coming into operation before the 1 January 2028 are exempt

[128] Directive (EU) 2018/2001; see also Tietze/Tsoumpa/Ullrich (2024), p. 6.
[129] Directive (EU) 2018/2001, Art. 29(3)–(5).
[130] Delegated Regulation (EU) 2023/1184; cf. Tietze/Tsoumpa/Ullrich (2024), p. 6.
[131] Delegated Regulation (EU) 2023/1184.
[132] Delegated Regulation (EU) 2023/1184.
[133] Delegated Regulation (EU) 2023/1184, Art. 5.

from the additionality requirement until the 1 January 2038, to avoid penalizing first movers during the market's ramp-up.[134]

Temporal correlation requires production to be matched to renewable generation within a defined time window. Until the 31 December 2029 the window is monthly — hydrogen output must correspond to renewable electricity generated in the same calendar month — whereas from the 1 January 2030 the matching becomes hourly, requiring production in the same one-hour period as the contracted renewable generation with Member States being able to bring the hourly rule forward, from the 1 July 2027, for fuels produced on their territory.[135] An exception treats this temporal correlation as met during hours in which the electricity price falls below a defined low-price threshold, taken as an indicator for a surplus of renewable generation in the system.[136]

Geographical correlation requires that the renewable installation and the electrolyzer lie in the same bidding zone, or in an interconnected bidding zone with an equal or higher electricity price, so that the renewable electricity claimed can plausibly reach the point of production.[137]

The Delegated Regulation also defines circumstances in which grid electricity may be treated as fully renewable under relaxed conditions. Where the electrolyzer operates in a bidding zone in which the average share of renewable electricity exceeded 90 % in the previous calendar year, grid electricity counts as fully renewable without a PPA, subject to a cap on production hours proportional to that share; where the emission intensity of grid electricity in the zone is below 18 gCO_2eq/MJ, it counts as fully renewable on the basis of a PPA with temporal and geographical correlation, but without the additionality requirement; and where the electricity consumed reduces the need to re-dispatch renewable generation, it counts as fully renewable for the periods concerned. Once a bidding zone has exceeded the 90 % share or fallen below the 18 g threshold in a calendar year, that status is deemed to persist for the subsequent five calendar years.[138] These exceptions are analytically relevant because they connect the electricity-sourcing rules directly to the emissions test discussed below, where a sufficiently decarbonized grid is presumed capable of delivering renewable hydrogen without triggering additional fossil generation.

[134] Transitional rule under Delegated Regulation (EU) 2023/1184.
[135] Delegated Regulation (EU) 2023/1184, Art. 6.
[136] Delegated Regulation (EU) 2023/1184, Art. 6.
[137] Delegated Regulation (EU) 2023/1184, Art. 7.
[138] Delegated Regulation (EU) 2023/1184, Art. 4(1)–(3).

The 70 % greenhouse gas emissions-savings threshold, whose methodology is specified in Delegated Regulation (EU) 2023/1185 and confirms that an RFNBO must achieve life-cycle emissions savings of at least 70 % relative to a fossil-fuel comparator fixed at 94 gCO_2eq/MJ.[139] In practice, the 70% requirement corresponds to a ceiling of approximately 28.2 gCO_2eq/MJ, or roughly 3.4 kg CO_2-equivalent per kilogram of hydrogen, where any production pathway exceeding that ceiling cannot qualify as RFNBO-compliant.[140] The methodology is a full life-cycle ("well-to-wheel") assessment: its boundary extends to the point of final use, capturing emissions from electricity supply, conversion, compression, transport, and storage as well as those released when the fuel is used, rather than production alone.[141] The use phase is therefore included, for e-fuels, however, the CO_2 emitted at combustion is offset by the credit for the biogenic and atmospheric carbon from which the fuel was synthesized. The treatment of the electricity input is decisive for the outcome: electricity supplied through a direct line or a compliant grid-plus-PPA arrangement is assigned an emission intensity of zero, whereas grid electricity taken without a qualifying PPA must be accounted for at the emission intensity of the national grid, which in many jurisdictions is sufficient to breach the 70 % threshold.[142] The electricity-sourcing rules of the first delegated act and the emissions methodology of the second are two expressions of the same underlying logic.

Finally, traceability means that the sustainability and emissions characteristics of a given quantity of RFNBO must remain physically linked to that quantity along the supply chain. This is achieved through a mass-balance chain of custody governed by Article 30 of the Directive and Implementing Regulation (EU) 2022/996 (different from the book & claim approach), and monitored through the Union Database, whose scope RED III extended beyond the transport sector, as established above.[143] Traceability is what allows a compliance claim, that a particular consignment meets the sourcing and emissions criteria, to be verified rather than merely claimed.

3.5.3. Governance and institutional architecture

The EU does not certify renewable hydrogen through a single organization with an internal governance body. Rather, it operates a multi-level regulatory architecture within which

[139] Directive (EU) 2018/2001, Art. 25(2); Delegated Regulation (EU) 2023/1185.
[140] Cf. IEA (n.d.).
[141] Delegated Regulation (EU) 2023/1185.
[142] Delegated Regulation (EU) 2023/1185.
[143] Directive (EU) 2018/2001, Art. 30; Implementing Regulation (EU) 2022/996.

certification is carried out by a range of actors, public and private. This differs in kind from a stand-alone scheme. Compliance may be evidenced either through national certification schemes established by the Member States or through voluntary schemes, operated by the private sector.[144]

The rules themselves are set by the EU legislator, the European Parliament and the Council, in the Renewable Energy Directive, and are operationalized by the European Commission through the delegated and implementing acts. The Commission additionally acts as the recognition authority, empowered to recognize such schemes as fit to verify compliance with the Directive's criteria, with this recognition carrying a legal validity of 5 years.[145] This recognition by the Commission is, strictly speaking, not mandatory, as Member States retain the option to accept evidence from schemes they consider reliable, but in practice Commission recognition is the operative gateway.[146] Recognition also eases the implementation of the Member States themselves, since a producer's evidence obtained under a Commission-recognized scheme must be accepted throughout the Union, with no further national evidence of compliance permitted to be demanded. A single recognition harmonizes verification across the internal market, sparing producers from seeking separate national approvals and Member States from operating parallel assessment procedures of their own.[147]

As established, the certification itself is operated by recognized schemes, with EU law prescribing the minimum governance requirements for these schemes. Article 3 of Implementing Regulation (EU) 2022/996 requires each voluntary scheme to maintain a governance structure securing sufficient legal and technical capacity, impartiality and independence, complemented by internal monitoring, complaints and transparency obligations.[148] By Commission Implementing Decisions of 19 December 2024, the Commission formally recognized three voluntary schemes as competent to verify RFNBO compliance: ISCC EU (Implementing Decision (EU) 2024/3176), CertifHy (Implementing Decision (EU) 2024/3180), and REDcert-EU (Implementing Decision (EU) 2024/3194).[149] The RSB followed one procedural step behind: in November 2025, its dedicated RFNBO and RCF

[144] Directive (EU) 2018/2001, Art. 30; cf. Tietze/Tsoumpa/Ullrich (2024), p. 6.
[145] Directive (EU) 2018/2001, Art. 30(4)–(6); Implementing Regulation (EU) 2022/996.
[146] Directive (EU) 2018/2001, Art. 30(9); Delegated Regulation (EU) 2023/1184, Art. 9.
[147] Directive (EU) 2018/2001, Art. 30(9) (where an economic operator provides proof or data under a scheme recognised pursuant to Art. 30(4) or (6), a Member State shall not require further evidence of compliance with the sustainability and greenhouse-gas criteria).
[148] Implementing Regulation (EU) 2022/996, Art. 3.
[149] Implementing Decisions (EU) 2024/3176 (ISCC EU), (EU) 2024/3180 (CertifHy) and (EU) 2024/3194 (REDcert-EU), all of 19 December 2024.

standard completed the Commission's technical assessment with a positive outcome, the stage of the recognition procedure that precedes the formal implementing decision, and RSB-accredited certification bodies began certifying RFNBOs on that basis.[150] The distinction between the two statuses has practical weight: only a formal recognition decision under Article 30(4) of the Directive obliges all Member States to accept the scheme's proofs without requiring further evidence of compliance (Article 30(9)), and it is granted for a limited period of usually five years. A positive technical assessment does not yet carry this effect; the Commission lists the scheme as positively assessed and certification may proceed, but acceptance of the resulting evidence remains within the discretion of individual Member States until the implementing decision is adopted.[151] As of August 2026, the RFNBO space therefore counts three formally recognized schemes, with RSB certifying in this interim status and its formal recognition still pending.[152] The existence of operational, EC-recognized RFNBO schemes is significant, as this means that a concrete certification route into the EU market already exists for third-country producers.

Beneath this recognition architecture sits the operational layer through which compliance is verified. Certification is confirmed not by self-declaration but by independent certification bodies, conformity-assessment bodies that contract with a recognized scheme to audit economic operators and issue certificates on its behalf.[153] Under Implementing Regulation (EU) 2022/996, such bodies must be accredited to ISO/IEC 17065 — and to ISO 14065 where they verify actual greenhouse-gas values — by a national accreditation body under Regulation (EC) No 765/2008, or recognized by a competent national authority, which supervises their conduct.[154] The audit is risk-based and recurrent: a new participant undergoes an on-site initial audit establishing the reliability of its internal processes, followed by surveillance audits whose frequency and depth rise with its assessed risk profile, and a re-certification audit to renew the certificate.[155] Throughout, auditors verify compliance with the sustainability and greenhouse-

[150] RSB's RFNBO/RCF standard (RSB-STD-11-103, v1.0) received a positive technical assessment from the Commission in November 2025, on the basis of which RSB reports that its accredited certification bodies can certify RFNBOs and RCFs, cf. RSB (2025a); the RSB EU RED scheme had already been recognized for a scope including RFNBOs by Implementing Decision (EU) 2022/607 of 8 April 2022.
[151] Directive (EU) 2018/2001, Art. 30(4) and (9).
[152] Cf. European Commission (n.d. b): the Commission's list of pending applications records RSB's extension to RFNBOs and RCFs as positively assessed but not yet recognized, status as of 31.08.2026.
[153] Implementing Regulation (EU) 2022/996, Art. 2(14) (definition of 'certification body').
[154] Ibid., Art. 11 (accreditation under Regulation (EC) No 765/2008; the accreditation requirement applies from 1 January 2027 pursuant to Implementing Regulation (EU) 2025/196); Directive (EU) 2018/2001, Art. 30(9) (supervision of certification bodies by national authorities).
[155] Ibid., Art. 2(16)–(17) and Annex III (annual scheme activity reports and Commission oversight).

gas criteria and with the mass-balance chain of custody at each stage of the supply chain, issuing the proofs of sustainability that are recorded in the Union Database, while the Commission retains oversight by requiring annual scheme activity reports and reserving the power to withdraw recognition.

3.5.4. Types of certification

The EU framework produces two conceptually distinct certificate types, and this distinction is not merely formal. It determines what a certificate can be used to demonstrate. The Proof of Sustainability (PoS) is defined as a declaration by an economic operator, based on a certificate issued by a certification body, attesting that a specific quantity of feedstock or fuel complies with the sustainability and greenhouse gas emissions-savings criteria.[156] The PoS therefore is a compliance instrument in the full sense, as it travels with the product under a mass-balance chain of custody, is entered into the Union Database, and can be used as proof of target fulfilment in accordance with Articles 25 to 30 of the Directive.[157] It is, as introduced in Chapter 3.1., a sustainability certificate, and is the instrument that matters for RFNBO market access.

The Guarantee of Origin (GoO) by contrast, serves a narrower, disclosure-oriented function. Defined in Article 19 of the Directive, a GoO provides evidence to a final customer that a given share of energy was produced from renewable sources.[158] It is issued in standard units of 1 MWh, must be issued, transferred, and cancelled in an accurate and fraud-resistant manner in accordance with the CEN-EN 16325 standard and, under RED III, has been extended to cover renewable gases including hydrogen, as well as heating and cooling.[159] A GoO discloses renewable origin but does not by itself demonstrate compliance with the emission-reduction criteria: it is not required to be submitted to the Union Database and serves no function in relation to Member States' compliance with the 2030 emission-reduction targets, unlike the PoS.[160] How the PoS carries this evidentiary weight follows from the certification mechanics. The fuel producer must provide reliable information demonstrating compliance with each of the electricity-sourcing rules, including records, for each hour where relevant, of the electricity used by sourcing category, of the renewable electricity generated in the contracted installations, and of the fuel produced; the underlying PPAs, the commissioning dates of the generation installations and the absence of operating or investment support substantiate

[156] Implementing Regulation (EU) 2022/996.
[157] Directive (EU) 2018/2001, Art. 25–30; Implementing Regulation (EU) 2022/996.
[158] Directive (EU) 2018/2001, Art. 19.
[159] Directive (EU) 2018/2001; CEN-EN 16325.
[160] Directive (EU) 2018/2001, Art. 19.

additionality.[161] A certification body accredited under a recognized scheme audits this documentation together with the greenhouse gas calculation and the mass balance, and the PoS is issued on the basis of the resulting certificate.[162] The criteria set of the Delegated Regulation is thus demonstrated in full by the PoS and the audit trail behind it, without recourse to Guarantees of Origin; the latter play no evidentiary role in RFNBO compliance and, to prevent the renewable attribute of the same electricity from being claimed twice, Guarantees of Origin issued for the electricity used are cancelled under Article 19 of the Directive.[163] In terms of the chain of custody models, the PoS is associated with mass balancing, whereas the GoO functions as an energy attribute certificate typically issued under a book-and-claim model.[164]

The consequence for an exporting producer is that renewable-origin evidence alone is insufficient for RFNBO status. This reinforces the point made in Chapter 3.1. that, for compliance purposes, evidence of renewable electricity origin is a necessary but not sufficient element of the required documentation.

3.5.5. Social dimension in the EU RFNBO framework

The picture that emerges from the preceding sections is that RFNBO eligibility rests on three technical pillars (renewable electricity sourcing, a 70 % greenhouse gas saving and mass-balance traceability), verified through certification and recorded in the Union Database. What the framework does not contain is any mandatory social sustainability criteria. Neither the Directive nor its delegated and implementing acts condition RFNBO status on labor standards, community engagement, water-related social impacts, land rights, or the consent of affected communities. Within the EU regime, these dimensions are simply not part of what it means for hydrogen to be “renewable”.

This absence is not an oversight peculiar to hydrogen but a structural feature of the EU’s sustainability-criteria architecture and it has been identified as such. It has been observed that, although many private certification schemes do integrate social prerequisites, social criteria are generally less present than environmental ones in the schemes recognized under the Directive, that their stringency is exposed to the same competitive pressure among schemes described in Chapter 3.4, and that schemes with civil-society actors in their governance and

[161] Delegated Regulation (EU) 2023/1184, Arts. 5 and 8.
[162] Delegated Regulation (EU) 2023/1184, Art. 9; Implementing Regulation (EU) 2022/996; for the scheme-level operationalization cf. ISCC EU 202-6.
[163] Delegated Regulation (EU) 2023/1184, recital 15, referring to Directive (EU) 2018/2001, Arts. 7 and 19.
[164] Cf. International PtX Hub (2023).

that schemes with civil-society actors on their governance boards tend to apply more stringent social criteria than industry-only ones.[165] The observation remains, as set out in Chapter 3.4., that the climate benefit of renewable hydrogen is captured by the binding EU criteria, while the social conditions of its production may be left to voluntary initiative.

If the Directive itself imposes no social conditions, the question arises how the EU addresses labor and human-rights concerns in the goods that it imports. These concerns are not routed through the energy-market-access rules at all, but through cross-cutting instruments that apply to products irrespective of type. The most directly relevant to imports is the Forced Labor Regulation, which from 14 December 2027 will prohibit placing or making available on the Union market, as well as exporting from the Union market, any product made wholly or partly with forced labor at any stage of its supply chain; since the prohibition applies regardless of sector or origin, imports are caught by the placing-on-the-market limb, reaching imported fuels and their inputs.[166] It is a market-access ban rather than a disclosure obligation, applies directly without national implementing legislation, and takes its definition of forced labor from the ILO Forced Labor Convention.[167] Broader human-rights and environmental coverage was to come from the Corporate Sustainability Due Diligence Directive, which requires in-scope companies to identify and address adverse impacts across their own operations and value chains, capturing the upstream production conditions of imported fuels.[168] That instrument's scope has since been revised: the Omnibus I amending directive of February 2026 raised the applicability threshold to companies with more than 5,000 employees and over €1.5 billion in net worldwide turnover, and deferred application to 26 July 2029. As a result, the mandatory social due-diligence duty will apply to a smaller set of importers than originally envisaged.[169] Sustainability reporting under the Corporate Sustainability Reporting Directive, itself also cut back by the same package, adds a disclosure layer, and for particular feedstocks product-specific regimes bite — notably the EU Deforestation Regulation, relevant to palm- and soy-

[165] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), p. 151.
[166] Regulation (EU) 2024/3015, Art. 3.
[167] Ibid. (definition by reference to the ILO Forced Labor Convention, 1930 (No. 29); product-based approach).
[168] Directive (EU) 2024/1760.
[169] Directive (EU) 2026/470 of 24 February 2026 (Omnibus I), in force 18 March 2026, amending Directive (EU) 2024/1760: revised scope (EU undertakings with more than 5,000 employees and net worldwide turnover above €1.5 billion; third-country undertakings above €1.5 billion EU turnover), transposition by 26 July 2028 and application from 26 July 2029, replacement of the EU-wide civil-liability regime with national law, and removal of the mandatory climate-transition-plan obligation.

derived biofuels, alongside narrower sector-targeted measures such as the Batteries and Conflict Minerals Regulations.[170]

This division of labor between environmental market-access rules and horizontal social instruments is not accidental. Embedding process-based social conditions, how a fuel was made, by whom, and under what labor conditions, directly into the criteria a product must meet to enter the market or count towards a target raises difficulties under World Trade Organization law. The non-discrimination disciplines of the GATT, in particular most-favored-nation and national treatment, require that imported goods be treated no less favorably than "like" domestic products, and two consignments of hydrogen are ordinarily regarded as "like" even if one was produced with forced labor, in unsafe conditions, or with heavy water use, because those differences lie in the process and production method rather than in the physical product.[171] An import restriction based on such conditions therefore risks being treated as disguised protectionism, and can be sustained only through the general exceptions of GATT Article XX. RED's carbon-intensity and land-use criteria fall comfortably within the environmental limbs of that provision — the exceptions for measures protecting human, animal or plant life or health and for conserving exhaustible natural resources — and are applied on the same terms to domestic and foreign producers, which is a central reason the EU frames its import criteria in environmental and technical terms.[172] An outright forced-labor ban is likewise defensible, but on a different footing: it rests on the "public morals" exception of Article XX(a), the limb the Appellate Body accepted in the EU Seal Products dispute, provided the measure is applied without arbitrary or unjustifiable discrimination.[173] Broader labor, safety and water criteria are far harder to defend, for there is no WTO jurisprudence recognizing general labor standards under the public-morals exception, and the membership has consistently deferred to the International Labor Organization as the competent body for core labor standards while declining to write a "social clause" into trade law.[174] It is largely for this reason

[170] Directive (EU) 2022/2464 (CSRD), as amended by Directive (EU) 2026/470; Regulation (EU) 2023/1115 (EU Deforestation Regulation); Regulation (EU) 2017/821 (Conflict Minerals Regulation); Regulation (EU) 2023/1542 (Batteries Regulation).
[171] GATT 1994, Art. I and III; on the process-and-production-methods ('like products') distinction cf. IISD (n.d.); European Parliament (2022).
[172] GATT 1994, Art. XX(b) and (g); see the environmental disputes US – Shrimp and US – Tuna.
[173] GATT 1994, Art. XX(a); Appellate Body Report, EC – Seal Products; on the Forced Labor Regulation resting on the public-morals exception cf. Herbert Smith Freehills (2024).
[174] WTO Singapore Ministerial Declaration (1996), deferring to the ILO on core labor standards; on the absence of Art. XX(a) jurisprudence on labor rights cf. Howse (1999).

that the EU keeps such social concerns in separate due-diligence and trade instruments rather than making them conditions for a fuel to enter the market or count toward its targets.

For an imported renewable-hydrogen product the practical consequence is a sharp asymmetry. A cargo of green ammonia or e-hydrogen must clear RED's carbon-intensity and additionality criteria, verified through certification and recorded in the Union Database, before it can count toward the EU's targets; but the social conditions of its production, worker safety, labor rights, competition for local water, are addressed, if at all, only through the forced-labor ban from the end of 2027, the narrowed due-diligence directive from 2029 and only for the largest firms, and whatever voluntary certification the producer chooses to layer on. Labor standards short of forced labor, production safety and water stress thus remain substantially outside the binding EU law specific to fuels, precisely the space that a dedicated social safeguards module, of the kind this thesis develops, could occupy without conflicting with the EU framework.

3.6. Regional certification in Latin America

3.6.1. Context and Rationale for a regional approach

The emergence of a dedicated regional certification initiative for Latin America and the Caribbean (LAC) reflects the structural realities of the region's hydrogen sector and the broader strategic logic of collective market positioning. As analyzed and established in the preceding subchapters, certification is not merely a technical mechanism but can be a foundational enabling condition for market participation. For producer countries in the Southern Hemisphere, access to regular markets, such as the European Union, depends on satisfying certification requirements that are established externally, in these respective markets. Through a region-specific initiative, the fragmentation that can result from divergent national systems can be avoided.

The conceptual groundwork for such an initiative was developed in a series of studies commissioned by the Inter-American Development Bank (IDB). An initial 2022 study provided one of the first analyses of hydrogen certification from the perspective of Latin American producers, mapping existing global schemes against the region's specific social, economic, and environmental context.[175] This was then followed by a 2023 implementation guide, which

[175] Cf. Ángel/Márquez (2022).

translated this analytical foundation into a concrete proposal for a harmonized regional certification system.[176]

The motivations behind a regional rather than purely national approach are outlined explicitly in the IDB guide and encompass four interconnected rationales:[177]

1. Market perspective: As hydrogen and derivatives are increasingly traded internationally, not only within the region but also with importing markets such as the EU, North America, and Asia, a shared certification system maximizes product value and facilitates eligibility across diverse markets.
2. Avoidance of redundant effort: Developing entirely separate certification systems in each country would duplicate resources and risks producing incompatible systems that complicate cross-border trade.
3. Regional counterweight in negotiations: A unified LAC certification framework provides exporting nations with a collective bargaining position when engaging with major economic blocks, particularly the EU.
4. Integration of region-specific attributes: Including sustainable water use, reduced socio-environmental impact, and land use considerations — that reflect the particular social and environmental context of LAC but may not be captured in externally designed certification frameworks.

The regional initiative was formalized on 8 November 2023, during OLADE's Energy Week in Montevideo, when the Ministries and Energy Secretariats of thirteen Latin American and Caribbean countries (Argentina, Bolivia, Chile, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Panama, Paraguay, the Dominican Republic, Trinidad and Tobago and Uruguay) signed the Joint Declaration for the Implementation of the Clean Hydrogen and/or Low Emissions Certification System in Latin America and the Caribbean; Mexico acceded at COP28 the following month, bringing the number of signatories to fourteen.[178]

The coordinating body designated to oversee the implementation of CertHiLAC is OLADE, the Latin American Energy Organization (Organización Latinoamericana de Energía), which provides the institutional backbone for the initiative.[179] OLADE is an intergovernmental organization established by the Agreement of Lima in 1973, headquartered in Quito and today

[176] Cf. Hartmann et al. (2023).
[177] Cf. Hartmann et al. (2023), p. 9.
[178] Cf. IDB (2023); OLADE (n.d.).
[179] Cf. Hartmann et al. (2023), p. 38.

comprising 27 member states of Latin America and the Caribbean.[180] It operates as a body for cooperation, coordination and technical advice in the energy sector, convening the region's energy ministers, maintaining regional energy data and studies, and supporting member states in policy development and capacity building rather than regulating them.[181] In comparison to the European Union, there is no supranational regulatory entity with binding authority over its members. This presents a structural challenge for consolidation, as the initiative depends on voluntary coordination among countries with differing institutional capacities, political priorities, and hydrogen sector maturity levels.[182]

The heterogeneity just described is illustrated by the region's largest hydrogen market, which has so far not signed the Declaration. Its absence is a policy choice, not a legal exclusion: the Declaration is a voluntary, non-binding instrument coordinated by OLADE that remains open to further accessions, as Mexico's adherence at COP28, weeks after the initial signing, illustrates, and the label-free, attribute-based design was chosen precisely so that the regional system and national regulations can coexist (Chapter 3.6.2).[183] Brazil has instead, for now, legislated nationally: Law No. 14.948 of 2 August 2024 defines low-carbon hydrogen as hydrogen whose life-cycle emissions do not exceed 7 $kgCO_2eq/kgH_2$ and establishes the Brazilian Hydrogen Certification System (SBCH2) as a voluntary scheme whose sole certified attribute is life-cycle emission intensity.[184] The law remained largely inoperative until Decree No. 13.096 of 12 August 2026 assigned the operational roles: the PNH2 Steering Committee as competent authority, the hydrocarbons regulator ANP as regulatory authority, the metrology institute Inmetro as accreditation body, and the electricity market chamber CCEE as registry operator.[185]

Two observations follow. First, Brazil has established at national level, and within two years, the institutional architecture — scheme authority, regulator, accreditation body, registry, accredited third-party certifiers — that CertHiLAC has yet to constitute regionally. The premise of the IDB guide, that binding hydrogen standards in the region were either absent or still in development, was accurate when written but has since been overtaken.[186] Second, and more

[180] Agreement of Lima (1973), Art. 1.
[181] Agreement of Lima (1973), Art. 2 and Art. 10.
[182] Cf. Hartmann et al. (2023), p. 10.
[183] Cf. Hartmann et al. (2023), pp. 8, 14 and 55 (voluntary character; guidance addressed to "countries interested in participating in the initiative"); on Mexico's accession at COP28 cf. IDB (2023).
[184] Lei No. 14.948/2024, Art. 4 XII, Art. 15 and Art. 22.
[185] Decreto No. 13.096/2026, Art. 19.
[186] Cf. Hartmann et al. (2023), ch. 3.1.

relevant to the argument pursued here, the Brazilian certificate carries emission intensity and nothing else. Social requirements are not absent from the Brazilian framework, but they attach to the fiscal incentive regime rather than to the certificate: eligibility for the Rehidro tax regime is conditioned on local content quotas and on the application of at least one per cent of total project value to sustainable development projects, explicitly including energy access for communities affected by the project and water security.[187]

Colombia, by contrast, demonstrates that a national regulatory framework and adherence to the regional initiative are fully compatible: it is a signatory and has legislated in parallel. Law 2099 of 2021 introduced the first legal definitions of green and blue hydrogen, delimited by energy source rather than by an emissions threshold.[188] The threshold was supplied later and by the executive: Decree 1597 of 2024 established the technology-neutral category of low-emission hydrogen and mandated a joint ministerial resolution to fix its limit, which Resolution 0900 of 17 July 2026 set at 3.6 $kgCO_2e/kgH_2$ on a life-cycle basis.[189]

Read together with the Brazilian figure of 7 $kgCO_2eq/kgH_2$, and even before differences in system boundaries are accounted for, the two national definitions illustrate the coordination problem that CertHiLAC's attribute-based, label-free design is intended to circumvent: neighbouring producer countries may each hold a legal definition of the same product while differing on where the line falls.

3.6.2. Fundamental characteristics of CertHiLAC

CertHiLAC is defined by five fundamental design characteristics:[190]

Voluntary nature: CertHiLAC is explicitly designed as a 100 % voluntary certification system. This choice reflects the regulatory reality of the region as, as of the date of the proposal, binding hydrogen standards or legal regulations were either in development or non-existent across most LAC jurisdictions. The goal is therefore not regulatory compliance but rather serving producers who seek to improve the market eligibility and transparency of their products, and consumers who wish to procure certified hydrogen for their decarbonization

[187] Decreto No. 13.096/2026, Art. 35 and Art. 37; statutory basis: Lei No. 14.948/2024, Art. 26 § 2 and Art. 27 § 6.
[188] Ley 2099 de 2021, Art. 5 (nos. 23 and 24, supplementing Art. 5 of Ley 1715 de 2014).
[189] Decreto 1597 de 2024, Art. 2.2.7.3.5; Resolución 0900 de 2026 (MinMinas/MinAmbiente) of 17 July 2026.
[190] Cf. Hartmann et al. (2023), pp. 14–16.

efforts. It is, however, designed with sufficient flexibility to serve as a compliance verification tool.

Precision: The certification system is crafted with a specific focus on key attributes pertinent to the regional and global stage. The attribute selection is targeted towards elements that align with the requirements and standards of target markets, while simultaneously allowing for straightforward and flexible implementation. The attributes considered include the energy source, as well as social and environmental impacts, elaborated below.

Openness to multiple production pathways: The system is explicitly designed to accommodate the diverse energy resource profiles and production technology mixes prevalent across LAC. It is not restricted to electrolytic hydrogen but encompasses a large range of clean and low-carbon hydrogen production pathways, while deliberately excluding hydrogen produced from fossil sources without carbon capture and storage. Biomass illustrates both the rationale and its limits. The guide grounds this openness partly in the coexistence of fossil and renewable biomass resources across the region and national definitions bear this out: Colombian law counts biomass among the non-conventional renewable sources from which green hydrogen may be produced, and Brazilian law classifies hydrogen obtained from biomass, ethanol and other biofuels as renewable hydrogen.[191] Under the EU definition however, an RFNBO is by construction a fuel whose energy content derives from renewable sources other than biomass. Biomass-based pathways can therefore be certified under the LAC category, but not under the EU-market category, which mirrors the RFNBO definition.

Flexibility and adaptability: The system is designed to accommodate certifications for both domestic consumption and export of hydrogen and its direct derivatives, including ammonia, methanol, and e-fuels. It is conceived as a dynamic framework that can be adapted to evolving market requirements, regulatory standards, and emerging trends without requiring a fundamental redesign.

Attribute-based and label-free: Drawing on lessons learned from CertifHy, Europe's first operational hydrogen certification system, which relies on color-based qualifiers such as "green" or "blue" hydrogen, CertHiLAC expressly avoids pre-established product labels or rigid thresholds. Instead, the system relies on the transparent reporting of key product

[191] Cf. Hartmann et al. (2023), p. 13.

characteristics, such as carbon intensity, energy sources, production technologies and other certified attributes.

Having established the base principles, the next step is to further examine the attributes relevant to this certification system. The selection of attributes reflects a comprehensive analysis of global hydrogen certification systems, benchmarked against the specific social, economic and environmental context of the region. Three types of attributes were identified, proposed and organized according to their applicability and certification category, as shown in Figure 3.[192]

Base attributes are those present in all certification systems worldwide, including the primary energy source and energy production plant information, hydrogen production plant information (including production technology, location and capacity), and the intensity and scope of GHG measurement.

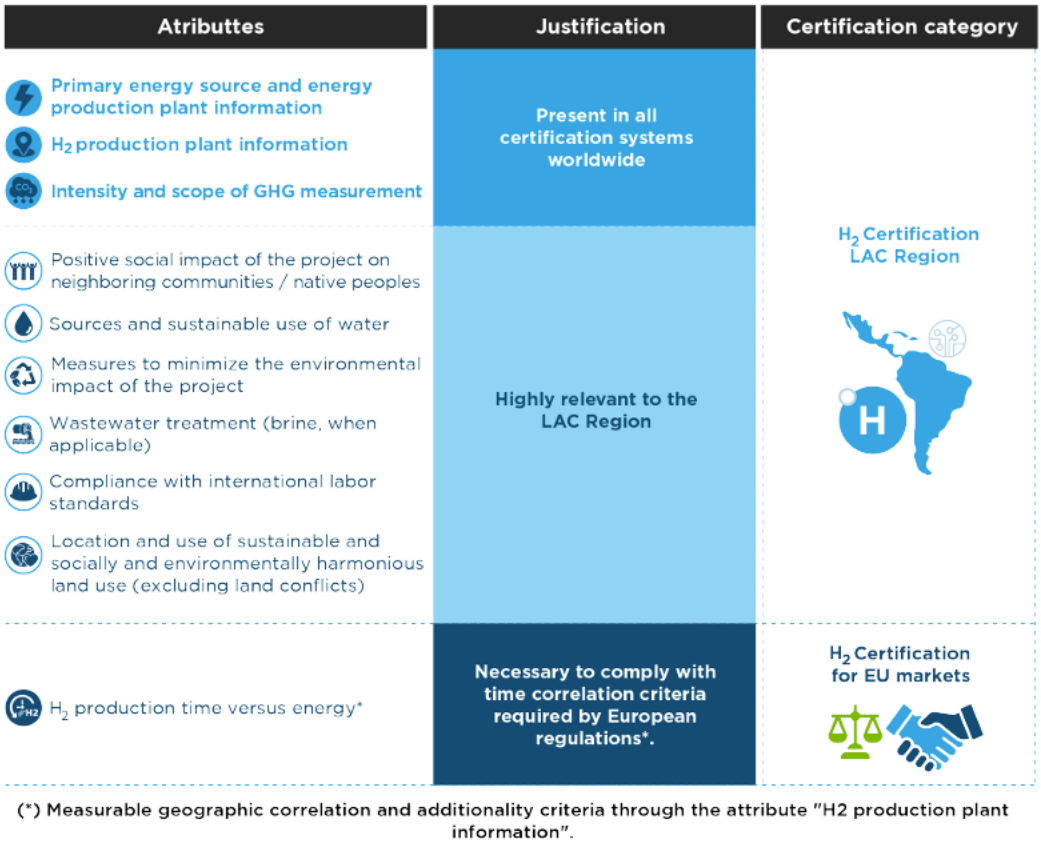
LAC-specific attributes are those considered highly relevant for the regional context, which constitute the most analytically significant attributes for the purpose of this thesis.[193] These are: the positive social impact of the project on neighboring communities and indigenous peoples; sources and sustainable use of water; measures to minimize the environmental impact of the project; wastewater treatment, specifically brine disposal from desalination processes where applicable; compliance with international labor standards; and location and use of socially and environmentally harmonious land, explicitly excluding land conflict areas.[194]

EU-specific additional attributes, required to meet the conditions of RED II, relevant therefore only for targeting the European market.[195] This entails the attribute of the time of hydrogen production relative to electricity generation as well as the geographical correlation.[196]

These three categories collectively constitute the two certification categories proposed by CertHiLAC: an "H2 Certification for the LAC Region" category encompassing the base and LAC-specific attributes, and an "H2 Certification for EU Markets" category that adds the EU-specific attributes and requires GHG accounting up to the point of final use, in compliance with RED II.[197]

[192] Cf. Hartmann et al. (2023), pp. 16 f.
[193] Cf. Hartmann et al. (2023), p. 17.
[194] Cf. Hartmann et al. (2023), p. 17.
[195] Cf. Hartmann et al. (2023), p. 17.
[196] Cf. Hartmann et al. (2023), p. 17.
[197] Cf. Hartmann et al. (2023), p. 17.

Figure 6: Proposed attributes to be included in a regional H_2 certification system in LAC (Source: Hartmann et al. (2023), p. 17)



3.6.3. Governance Structure

The governance model proposed for CertHiLAC reflects the multi-country, multi-stakeholder nature of the initiative and draws explicitly on established precedents from other certification systems, most notably the CertifHy scheme in Europe and the I-REC renewable electricity certification system.[198] Core roles are defined in the proposed governance framework: the System Representative, the Coordinator and Administrator, the Registry Operator, and national Certificate Issuers, while Auditors operating as independent verification bodies complete the structure.[199]

The System Representative constitutes the decision-making authority within the system, responsible for defining rules and requirements, ensuring proper functioning, selecting and approving stakeholders involved, and validating system modifications.[200] Additionally, the

[198] Cf. Hartmann et al. (2023), pp. 25–35.
[199] Cf. Hartmann et al. (2023), pp. 25–35.
[200] Cf. Hartmann et al. (2023), pp. 38 f.

requirements for the Coordinator and Administrator are defined by the System Representative as well as specifying the players that comprise the Stakeholder Group.[201] The System Representative is to be composed of two representatives appointed by each signatory country, ideally stemming from energy ministries and secretariats, national development agencies, and/or electricity market operators.[202] These are expected to hold stable, technically oriented positions with minimal political fluctuation.[203] Crucially, this design distinguishes CertHiLAC from fully private-sector-driven schemes, in which no government representation on governance committees is foreseen.[204] This integration is intended to foster harmonization with national regulations and standards, and to validate emissions measurement methodologies against national emissions inventories.[205]

The role of Coordinator and Administrator encompasses the execution and day-to-day management of the system, including ensuring transparent processes and clear rules, as well as providing operational support and guidance to issuers, certification bodies, and auditors.[206] This role requires an understanding of the market and the technologies to be certified, as well as management and coordination expertise.[207] The guide proposes that OLADE, designated as the coordinating entity by the signatory countries in the CertHiLAC Declaration, could also assume the role of system administrator — with the same entity potentially also taking on the Registry Operator role depending on its capabilities, thereby further consolidating governance and reducing the number of distinct actors involved.[208]

The Registry Operator is the organization responsible for maintaining the records and technical infrastructure of certificates and operating the registry database.[209] Its primary function is to avoid double counting, and must therefore operate under close supervision of the system administrator, or serve as a contractor to that administrator.[210] The guide proposes a single, integrated regional certificate registry for all participating countries, and recommends

[201] Cf. Hartmann et al. (2023), pp. 38 f.
[202] Cf. Hartmann et al. (2023), pp. 38 f.
[203] Cf. Hartmann et al. (2023), pp. 30 and 39.
[204] Cf. Hartmann et al. (2023), p. 11.
[205] Cf. Hartmann et al. (2023), p. 11.
[206] Cf. Hartmann et al. (2023), p. 30.
[207] Cf. Hartmann et al. (2023), p. 30.
[208] Cf. Hartmann et al. (2023), pp. 30 and 35.
[209] Cf. Hartmann et al. (2023), p. 31.
[210] Cf. Hartmann et al. (2023), pp. 31 and 35.

that an entity experienced in such tasks fulfill this role — citing Evident, the operator of the I-REC and I-REC H2 systems, as a concrete example.[211]

The Certificate Issuer is an operational role, working closely with hydrogen production facilities seeking certification, providing guidance throughout the process until certificates are issued, and potentially also training certification bodies and auditors in accordance with system rules.[212] The Issuer must be authorized by the System Representative, comply with the requirements it sets and it is recommended that issuers operate at the national level, based on considerations of cost-effectiveness, local market development, and regulatory compliance.[213] The guide notes that countries, such as Argentina, Brazil, Chile, Colombia and Uruguay already have local issuers of renewable energy certificates that could transition into this role for hydrogen certification.[214]

Auditors are responsible for visiting production plants and evaluating whether they meet the criteria and attributes established by the system.[215] Each country determines the modalities for their appointment based on the minimum requirements set by the system.[216] The recommendation is to designate multiple accredited auditors, also referred to as certification bodies, with a progressive approach, expanding as the market grows.[217] While the guide acknowledges that in theory an issuer could also perform the auditor role, it explicitly recommends maintaining two separate entities in order to prevent fraud and enhance the system's credibility.[218]

With respect to the overall configuration of issuing bodies and the certificate database, the guide considers different combinations, but finally recommends a national-level issuing body, paired with a single unified regional record database.[219] This aims to leverage existing national institutional capacities, while ensuring consistency, preventing double counting and supporting regional coordination.[220]

[211] Cf. Hartmann et al. (2023), pp. 31 and 35.
[212] Cf. Hartmann et al. (2023), pp. 31–32 and 35.
[213] Cf. Hartmann et al. (2023), p. 32.
[214] Cf. Hartmann et al. (2023), p. 28.
[215] Cf. Hartmann et al. (2023), p. 33.
[216] Cf. Hartmann et al. (2023), p. 33.
[217] Cf. Hartmann et al. (2023), p. 33.
[218] Cf. Hartmann et al. (2023), pp. 33 and 36.
[219] Cf. Hartmann et al. (2023), pp. 27 f.
[220] Cf. Hartmann et al. (2023), pp. 27 f.

3.6.4. EU Compatibility

The dual-category structure of CertHiLAC reflects a fundamental tension at the heart of regional certification design: the need to serve local and intraregional markets with their region-specific sustainability requirements, and to position the region competitively for access to highly regulated export markets, foremost the EU.

The “H2 Certification for LAC Region” category captures the base and LAC-specific attributes described above, with GHG accounting extending to the point of hydrogen production (Well-to-Gate), consistent with the predominant practice among voluntary hydrogen certification systems.[221] It attaches no specific GHG intensity threshold: consistent with the attribute-based, label-free design (Chapter 3.6.2), the measured well-to-gate intensity is reported as a certified value, and whether that value suffices is left to the buyer or to the regulation of the destination market; a threshold enters only where an external benchmark is certified against, as in the EU-market category below with its 70 % greenhouse gas saving requirement, or where national law sets one, as in Brazil and Colombia (Chapter 3.6).[222]

The “H2 Certification for EU Markets” category builds on the first, incorporates the additional requirements mandated by the EU RED II, including temporal correlation of electricity generation and hydrogen production, additionality, and the geographical correlation.[223] Furthermore, the GHG accounting boundary is extended to Well-to-Wheel, as required by RED II, to explicitly target RFNBO eligibility for the EU market.[224]

At the time of the preparation of the IDB guide in 2023, no voluntary scheme had yet been recognized by the Commission for RFNBO purposes. Producers seeking to export hydrogen or derivatives to EU markets and claim RFNBO status are, in practice, required to obtain certification under a scheme accepted by the EC — at the time of writing of the IDB guide, CertifHy's RFNBO compliance scheme and ISCC EU were undergoing review for this purpose.[225] The IDB guide acknowledges this limitation explicitly and recommends that, initially, LAC producers targeting the EU market use the first CertHiLAC category domestically while simultaneously obtaining certification under an EC-accepted scheme for export

[221] Cf. Hartmann et al. (2023), p. 20.
[222] Cf. Hartmann et al. (2023), pp. 8 and 14 f.
[223] Cf. Hartmann et al. (2023), p. 20.
[224] Cf. Hartmann et al. (2023), p. 20.
[225] Cf. Hartmann et al. (2023), p. 22.

documentation purposes.[226] It further envisions that, once CertHiLAC reaches a sufficient level of consolidation, a formal application for EC recognition could be pursued — though acknowledging this to be a complex and multi-year process.[227]

3.6.5. Implementation Status and Outlook

The proposed action plan structures the implementation process into three consecutive steps.[228] Step 1 encompasses the establishment of the System Representative and the definition of its governance, the identification of the required development budget and funding sources, an initial training and sensitization program for country representatives, the mapping of relevant stakeholders, the formation of a Stakeholder Group with thematic technical working groups, and the formal definition of the certification system's design and attributes.[229] Step 2 covers the identification of required data from participating countries, the determination of operating costs, and the definition of certification fees for producers.[230] Step 3 constitutes the actual operation of the system, initiated through a pilot project or projects designed to validate system functionality and scalability before full regional deployment, with the possibility of conducting multiple pilots to account for the heterogeneity of LAC countries.[231]

The action plan does not, however, schedule the element without which no certification system can operate. The registry appears as a governance role and as a cost item, and Step 2 provides for compiling the list of data that countries would need to supply in order to populate the certificate database, but its procurement, construction and funding are assigned to no step and no date; Step 3 simply presupposes it. Building tracing infrastructure is slow even where a legislator can compel it, which is why its absence from the regional plan is consequential rather than merely untidy.

In terms of concrete implementation progress, the OLADE Technical Note of June 2025 confirms that the regional governance scheme of CertHiLAC has already been defined, and that OLADE is actively pursuing complementary initiatives to strengthen regional certification capacity.[232] At the same time, publicly available information does not yet confirm the formal constitution of the System Representative body, the appointment of national Certificate

[226] Cf. Hartmann et al. (2023), p. 22.
[227] Cf. Hartmann et al. (2023), p. 22.
[228] Cf. Hartmann et al. (2023), pp. 36–54.
[229] Cf. Hartmann et al. (2023), p. 37.
[230] Cf. Hartmann et al. (2023), pp. 36–54.
[231] Cf. Hartmann et al. (2023), pp. 36–54.
[232] Cf. OLADE (2025).

Issuers, nor the issuance of any certificates under the system. The initiative thus remains, as of the time of writing of this thesis, in an early implementation phase: the political commitment and governance architecture are in place, but the transition from framework to functioning system is still underway.

The contrast with the alternative route is instructive. While no certificate has yet been issued under CertHiLAC, producers in the region have in the meantime been certified under the schemes recognized by the Commission: HIF Global's Haru Oni facility in Chile obtained ISCC EU RFNBO certification in October 2025, the first facility outside the EU to do so, and renewed it in July 2026 (see Chapter 4.3).[233] The value the regional system can add therefore does not lie in providing access to the European market, which is already obtainable, but in what it certifies beyond it.

4. Hydrogen in Uruguay

4.1. Uruguay's renewable energy base and hydrogen ambition

Uruguay's interest in renewable hydrogen does not arise in isolation but builds directly on the outcome of an earlier energy transition. Between 2017 and 2020 the country decarbonized its electricity matrix to a share of roughly 97 % renewable generation, a transformation the national Green Hydrogen Roadmap explicitly frames as the completed "first stage" of its energy transition and as the point of departure for a hydrogen economy.[234] This renewable share fluctuates year on year due to hydrological conditions, given the weight of hydropower in the system: in the drought-affected year 2023 the renewable share of generation fell to approximately 88.5 %, whereas the final National Energy Balance for 2024 records 99 % in the national interconnected system (SIN).[235] [236] Placed in international perspective, this lower bound remains exceptional on both of the measures that matter for hydrogen. Measured by the renewable share of generation, renewables supplied more than one third of global electricity in 2025, the first year in which they overtook coal, and 48 % in the European Union.[237] Measured by carbon intensity, the average kilowatt-hour generated worldwide carried 473 gCO_2 in 2024 and the EU average 213 gCO_2, against 6.3 gCO_2 for the Uruguayan national interconnected system in the same year according to the emission factor published

[233] Cf. HIF Global (2025).
[234] Cf. MIEM (n.d. e).
[235] ADME data for 2023, cited in Dinámica RG (2024).
[236] Cf. MIEM (n.d. d).
[237] Cf. Ember (2026a) and Ember (2026b), data year 2025 in each case.

with the National Energy Balance, equivalent to 1.74 gCO_2/MJ.[238] Uruguay's electricity was thus roughly seventy-five times less carbon-intensive than the global average, and about thirty-four times less than that of the market it would supply. Both measures are subject to the same hydrological variability. The preliminary balance for 2025 records a renewable share of 98 %, and the emission factor rose to 12.1 gCO_2/kWh (3.37 gCO_2/MJ), nearly double that of the preceding year, following a decline in hydropower output; in the drought year 2023 it had stood at 56.0 gCO_2/kWh (15.6 gCO_2/MJ), and in 2021 at 100.8 gCO_2/kWh (28.0 gCO_2/MJ).[239] For renewable hydrogen this matters directly, as a near-fully renewable grid places Uruguay in a structurally favorable position relative to producer countries dependent on fossil fuel power, and the values acquire regulatory meaning when set against the EU framework: Delegated Regulation (EU) 2023/1184 allows grid electricity to be counted as fully renewable, under further conditions, where the renewable share of the bidding zone exceeded 90 % in the previous calendar year or where its emission intensity lies below 18 gCO_2eq/MJ (Chapter 3.5.2). Uruguay's grid met both benchmarks in 2024 and 2025, remained below the intensity threshold with a narrowing margin in the drought year 2023, and exceeded it in 2021; what this variability implies for the design of the pathway is examined in Chapter 6.2.1.

Beyond the electricity matrix itself, Uruguay's official investment agency identifies a specific combination of locational advantages for hydrogen and derivatives production: a high potential for additional onshore and offshore renewable generation well in excess of domestic demand, the availability of biogenic CO_2 from biomass, high water availability, and adequate export logistics.[240] The availability of biogenic CO_2 is particularly consequential for the derivatives on which this thesis focuses. Because e-methanol and e-fuels are synthesized by combining renewable hydrogen with a carbon source, access to CO_2 of biogenic rather than fossil origin, is what allows the resulting fuel to qualify as renewable under EU regulation. Uruguay's agro-industrial base, and in particular the fermentation and biomass operations of ALUR (the biofuels subsidiary of the state company ANCAP), provides such a source at scale.[241] The country's then Minister of Industry, Energy and Mining publicly characterized the availability of biogenic CO_2 as a competitive advantage over other aspiring producers.[242] On the logistics

[238] Cf. IEA (2025b), values for 2024.
[239] Cf. MIEM (2026), values for 2021, 2023 and 2025.
[240] Cf. VUI (n.d.).
[241] Cf. VUI (n.d.).
[242] Cf. Gas Outlook (n.d.).

side deep-water port infrastructure is being positioned as an export platform for ammonia and e-fuels.[243]

These endowments are, moreover, unusually close to one another. Uruguay's small territory places resource, conversion and export functions within short distances, and the two flagship projects illustrate the pattern: HIF's Paysandú development is sited beside the ALUR biofuels plant that supplies its biogenic CO_2, while the Tambor project lies in Tacuarembó, the northern terminus department of the Ferrocarril Central — the 273-kilometre freight line between Paso de los Toros and the port of Montevideo, in commercial operation since April 2024.[244] This proximity carries a corollary that matters for the argument developed later. Because the resource base, the conversion plants and the export corridor coincide geographically, the physical footprint of the sector, dedicated generation parks, transmission lines, construction workforces, concentrates in a small number of low-density departments rather than dispersing across the country.

These conditions are translated into a strategic target framework by the Green Hydrogen Roadmap, published in its final version in November 2023 under the coordination of the Ministry of Industry, Energy and Mining (MIEM).[245] The Roadmap projects that by 2040 hydrogen production could approach one million tons per year, requiring the installation of approximately 18 GW of renewable capacity and 9 GW of electrolysis, and estimates that a hydrogen and derivatives industry could generate an annual turnover of around USD 1.9 billion with more than 30,000 jobs created.[246] It frames the largest export potential as lying in methanol and maritime and aviation fuels, while the domestic market is centered on heavy transport that is difficult to electrify as well as fertilizer production.[247]

Two features of this ambition are analytically relevant for the argument developed in the following chapters and are noted here as the author’s own framing. First, the framework is explicitly export-oriented and names hydrogen derivatives destined for demand markets. Second, the combination of an already near-decarbonized grid with abundant renewable potential means that the technical and emissions-related hurdles to RFNBO eligibility, are comparatively low. This is precisely the reasoning that qualifies Uruguay as a critical case in the sense set out in Chapter 2.4.

[243] Cf. HyUruguay (2025).
[244] Cf. Sacyr Concesiones (n.d.).
[245] Cf. MIEM (2023).
[246] Cf. MIEM (2023).
[247] Cf. MIEM (2023).

4.2. The evolving regulatory and institutional framework

Uruguay's regulatory framework has evolved incrementally, by integrating hydrogen into existing legal instruments and by building a programmatic coordination layer on top of them.

The institutional foundations were laid in 2021 and 2022. The 2021 national budget law expanded the mandate of the energy and water regulator URSEA to include the oversight of hydrogen activities, and the 2022 budget law authorized the state company ANCAP to produce, distribute, commercialize, import and export green hydrogen and its derivatives in open competition.[248] The decisive institutional step was a coordinating one: Presidential Resolution 294/022 entrusts the Ministry of Industry, Energy and Mining with implementing and administering the "Programa H2U", and defines its fields of action as innovation, regulatory development, investment attraction, capacity building, international cooperation, infrastructure and logistics, assessment of offshore potential, and communication.[249] The same instrument establishes an inter-institutional hydrogen group convening the ministries of industry, energy and mining, environment, foreign affairs, economy, transport and housing as well as the planning office, with the regulator and the state companies participating on request.[250] The allocation of responsibility matters for what follows. Hydrogen policy is institutionalized as a cross-cutting, whole-of-government task. This programmatic layer was given strategic direction by the Green Hydrogen Roadmap, mentioned above.

The fiscal dimension developed along a distinct track. Since February 2022, renewable hydrogen has been eligible under the general regime of the Investment Promotion Law (Law No. 16.906 of 1998), when it was incorporated into the indicator matrix used by the application commission COMAP to qualify projects for tax benefits.[251] A first funding instrument followed in March 2022, when MIEM, the technology laboratory LATU and the research agency ANII created the Green Hydrogen Sectoral Fund to finance pilot, research and training projects.[252] Through this fund, the country's first pilot project was awarded up to USD 10 million in non-reimbursable support over ten years.[253] The treatment under the Investment Promotion Law was consolidated by Decree No. 329/025, promulgated in December 2025 and in force since 1 February 2026, which restructured the evaluation matrix and incorporated the renewable

[248] Ley No. 19.996 of 3 November 2021, Arts. 171 f. (URSEA competences for hydrogen); Ley No. 20.075 of 20 October 2022, Art. 234 (ANCAP); cf. MIEM (n.d. g).
[249] Resolution No. 294/022 of the Executive Power of 20 December 2022.
[250] Cf. MIEM (n.d. b).
[251] Cf. MEF (n.d.).
[252] Cf. MIEM (n.d. c).
[253] Cf. Energía Estratégica (2024).

hydrogen and derivatives value chain as a strategic activity, granting additional tax exemptions.[254]

The third regulatory layer concerns environmental and social governance. At the project level, hydrogen installations pass through the Ministry of Environment's staged licensing cascade, from Environmental Location Viability (VAL) through Prior Environmental Authorization (AAP) to the Environmental Impact Assessment, with major projects processed under the "high complexity" regime.[255] At the sector level, Uruguay launched a Strategic Environmental Assessment (Evaluación Ambiental Estratégica, EAE) of the entire renewable hydrogen and derivatives value chain, led jointly by the Ministry of Environment and MIEM with support from the development bank CAF.[256] It opened with an inter-institutional workshop in Montevideo on 15 September 2025 and continued with territorial sessions in Tacuarembó and Paysandú in March 2026.[257] The process is designed to assess strategic environmental, social and economic impacts across the value chain with the participation of technical, social and community actors.[258] The EAE is analytically significant because it is the first instrument in the Uruguayan framework that addresses the social and territorial dimension of hydrogen development systematically.

The regulatory framework has certainly matured on the enabling side: competences, coordination, fiscal incentives and licensing. Instruments that would govern the attributes of the hydrogen itself still remain outstanding, as Uruguay has neither a national hydrogen certification scheme nor a hydrogen-specific guarantee-of-origin regime. The underlying infrastructure for guarantees of origin already exists for renewable electricity through the SCER certificate system established by Decree No. 259/021 in 2021.[259] Two directions are already visible. Internationally, RFNBO compliance has been pursued as an explicit work stream: under the memorandum of understanding signed in May 2023 between the Port of Rotterdam, MIEM, the Ministry of Transport and Public Works and the National Ports Administration, a study was commissioned assessing how hydrogen derivatives produced in Uruguay can be certified as RFNBOs, which recognized certification systems are available for that purpose, and how the country performs against the individual criteria.[260] The analytical

[254] Decree No. 329/025.
[255] Cf. UyPress (n.d.).
[256] Cf. Ministerio de Ambiente (n.d.).
[257] Cf. Ministerio de Ambiente (n.d.); Ministerio de Ambiente/OAN (n.d. a).
[258] Cf. Ministerio de Ambiente (n.d.).
[259] Decree No. 259/021; cf. International PtX Hub (2024).
[260] Cf. Hinicio (2024).

groundwork for compliance therefore exists and is publicly documented; what is absent is the instrument through which compliance would be evidenced. The second direction concerns access to a low-emission hydrogen certification mechanism developed with OLADE and the IDB, corresponding to the regional CertHiLAC initiative examined previously. It remains an open question whether these strands consolidate into a national certification framework, an adoption of CertHiLAC, or direct reliance on an EU-recognized voluntary scheme.

4.3. Renewable hydrogen projects in Uruguay

The current hydrogen landscape in Uruguay falls into two distinct segments: a small operational or near-operational segment of pilot-scale projects, and several large, export-oriented megaprojects that remain in the permitting, assessment or design phase ahead of a final investment decision.[261] The projects surveyed below matter to this thesis in two respects: they demonstrate that Uruguay's export ambition is materializing in concrete ventures oriented largely towards the European market, and they supply cases against which Chapter 4.4 identifies the socially relevant dimensions of hydrogen development in the country. The two segments are therefore treated separately below. They differ not only in scale but in the conditions to which they are subject: the pilot projects serve domestic demand and carry a correspondingly limited physical footprint, whereas the export projects are the ones for which EU eligibility becomes a binding condition and whose land, water and workforce requirements give rise to the risks examined in Chapter 4.4

The Kahirós project near Fray Bentos (Río Negro) plans 4.8 MW of solar generation, a 2 MW electrolyzer with an annual production of 76.7 t of hydrogen for heavy-goods trucks.[262] It is the first integrated renewable hydrogen project for freight transport in Uruguay and is pilot in character: the produced hydrogen supplies six Hyundai fuel-cell trucks that transport timber to the Montes del Plata pulp mill.[263] The consortium comprises the Uruguayan firms Ventus, Fidocar and Fraylog, with Montes del Plata as client and the Grupo Santander as investor and asset owner.[264] Financing includes a USD 20 million green loan from the IFC and a USD 1 million loan from the UN Renewable Energy Innovation Fund, for a total investment of around

[261] Cf. UyPress (n.d.).
[262] Cf. Hyundai Uruguay (n.d.); World Bank (2025a).
[263] Cf. World Bank (2025a).
[264] Cf. World Bank (2025a).

USD 38.6 million.[265] The project is under construction, with operations expected by the end of 2026.[266]

The H24U project at Pueblo Centenario (Durazno) was the first pilot to be supported by the Green Hydrogen Sectoral Fund (with up to USD 10 million in non-reimbursable funding over ten years).[267] It is listed with 10 MW of generation, a 5 MW electrolyzer and 263 t of hydrogen per year for heavy transport and future grid injection.[268] Selected in 2023, the project has not advanced to implementation: MIEM's project inventory continues to list it at the feasibility-study stage, no environmental application has been publicly reported, and a study published in November 2025 by the German-Uruguayan Chamber of Commerce and Industry under the H2Uppp programme records the project as temporarily paused.[269]

HIF Global's Paysandú project envisions 2 GW of dedicated renewables generation (1.34 GW wind, 0.66 GW solar), a 1 GW PEM electrolyzer, resulting in an annual production of 100,000 t of hydrogen converted into 180,000 t of gasoline for export, the configuration announced at the pre-feasibility stage.[270] Recent figures describe an investment of over USD 5.3 billion, which would make it the largest private investment in Uruguay's history.[271] The plant would combine the renewable hydrogen with biogenic CO_2 from ALUR to produce e-fuels (e-methanol and synthetic gasoline) for export primarily to Europe and Asia, developed in four phases towards a capacity of up to roughly 880,000 t per year of synthetic fuels, with first exports planned for 2029.[272] At full build-out across four production trains the project is registered with the Ministry of Environment at a nominal annual capacity of 876,000 t of e-methanol and 313,390 t of e-gasoline, the latter obtained by onward conversion of part of the methanol, from an annual hydrogen output of 170,540 t. Water abstraction is given as 2,076 m³/h, of which 75 % is drawn from the Río Uruguay, and the CO_2 as originating from the ALUR plant together with on-site combustion of forestry residues sourced within roughly 300 km.[273] The generation is to come from two dedicated parks, the "Lucía" solar park and the "Elena" wind park, whose prior-authorization applications were submitted in the fourth quarter of

[265] Cf. World Bank (2025a).
[266] Cf. MercoPress (2025); H2 View (2026).
[267] Cf. Energía Estratégica (2024).
[268] Cf. MIEM (n.d. f).
[269] Cf. MIEM (n.d. f) (project inventory, status "feasibility studies"); AHK Uruguay/GIZ H2Uppp (2025), section 2 („temporalmente pausado").
[270] Cf. MIEM (n.d. f).
[271] Cf. MercoPress (2026).
[272] Cf. TankTerminals (2025); Rio Times (2026).
[273] Cf. Ministerio de Ambiente/OAN (n.d. b); Ministerio de Ambiente/OAN (2025a).

2025.[274] On the permitting side, the environmental process began in the first quarter of 2024 and the project obtained Environmental Location Viability (VAL) on 27 November 2025, and the application, including the environmental impact study, was submitted to DINACEA on 13 March 2026. In December 2025 HIF signed a memorandum of understanding with the government establishing the technical and institutional milestones of the pre-investment phase, including two joint follow-up bodies, a high-level committee composed of the Secretary of the Presidency, the ministers responsible for economy and finance, industry and energy, environment, and transport and public works, together with company representatives, and a technical committee for day-to-day follow-up, as well as the rehabilitation of rail links to the port of Montevideo.[275] Estimates of employment vary between the operator's more recent figure of around 1,400 construction jobs and 300 permanent positions and an earlier figure of around 3,000 construction jobs.[276] In February 2026 HIF signed a Heads of Agreement with German eFuel One GmbH for approximately 100,000 t of e-methanol per year from Paysandú, delivered through the port of Hamburg, following a comparable portfolio-level agreement with MB Energy (Mabanaft) in 2025.[277]

HIF also grounds the feasibility of the RFNBO pathway that is central to this thesis. The same operator runs the Haru Oni facility in the Magallanes region of Chile, where it has produced e-fuels for about three years and completed several exports.[278] HIF announced the certification on 1 October 2025 for the 2025/26 fiscal year and its renewal on 6 July 2026, the facility being recognized for the second time under the ISCC EU framework; the certificate is issued by TÜV SÜD and covers the entire value chain, from CO_2 sourcing through hydrogen production to e-methanol, e-gasoline and e-LG (liquefied gas).[279] This precedent is significant because it demonstrates that the EU certification pathway is not merely theoretical for a Latin American producer: the operator building Uruguay's flagship project has already navigated it in a neighboring country with a comparable renewable profile.

The Tambor project in Tacuarembó is another megaproject and is oriented towards e-methanol export towards the EU. It includes 470 MW of generation, a 150 MW electrolyzer, reaching a production of 13,000 t of hydrogen per year and 70,000 t of methanol for export.[280] VAL was

[274] Cf. HIF Global (n.d. a).
[275] Cf. Advanced Biofuels USA (n.d.); HIF Global (n.d. a).
[276] Cf. TankTerminals (2025); HIF Global (n.d. a).
[277] Cf. HIF Global (2026a).
[278] Cf. Advanced Biofuels USA (n.d.).
[279] Cf. HIF Global (2026b).
[280] Cf. MIEM (n.d. f).

presented in December 2021 by the German company developing the project, ENERTRAG, together with the Uruguayan firm SEG Ingeniería, producing renewable e-methanol from renewable hydrogen and biogenic CO_2 intended in part to replace around 10 % of the methanol conventionally produced at Germany's largest methanol production site.[281] The investment is estimated at around USD 1 billion with roughly 1,300–1,400 construction jobs estimated.[282] The application for Prior Environmental Authorization, including the environmental impact study, was submitted on 31 December 2024. The Ministry of Environment responded on 18 February 2025 with objections spanning the water study, production capacity, energy demand, use of the road through Tambores and the accommodation of the construction workforce, finding the documentation not to conform to the terms of reference.[283] The operator has responded in stages since: water demand was fixed at 675 m³ per day, of which 660 m³ industrial, to be met exclusively from surface water via a rainwater reservoir to be built some 3.5 km from the industrial site, and abstraction from the Guaraní aquifer was ruled out as a primary source.[284] The file remains under evaluation, with the developer describing processing as being at an advanced stage.[285] The project is additionally supported under H2Uppp, the German International Hydrogen Ramp-Up Programme implemented by GIZ, through a public-private partnership signed with ENERTRAG in 2026 with a regional focus (implementation in both Colombia and Uruguay). The contribution is directed at reducing early-stage development risk and covers studies on export infrastructure and logistics (specifically for Colombia), knowledge transfer, and the development of a community engagement strategy for the project's local setting, which the partners identify as one of its priorities.[286]

A further large-scale venture has been announced without entering the environmental process. Alfanar Energía España, the Spanish arm of the Saudi group Alfanar, presented to the government in 2024 a project for green ammonia and hydrogen production in Rocha, drawing on some 3,000 MW of wind and solar generation to be developed between La Pedrera and Barra del Chuy, with investment reported at no less than USD 6 billion and output destined for European markets.[287] Public information has remained thin: the state utility UTE approved a confidentiality agreement with the company by board majority in August 2024, a step a UTE

[281] Cf. H2LAC (n.d.); ENERTRAG (n.d.).
[282] Cf. pv magazine Latinoamérica (2022).
[283] Cf. El Observador (2025a).
[284] Cf. El Observador (2025b); Ministerio de Ambiente/OAN (n.d. c).
[285] Cf. ENERTRAG (n.d.).
[286] Cf. GIZ (2026b).
[287] Cf. Canal 9 Telerocha (2024a) (based on reporting by Semanario Búsqueda).

source described in the reporting as customary for companies seeking to establish themselves in the country. The board member representing the Frente Amplio, then in opposition, Fernanda Cardona, voted against and publicly criticized the agreement as a "blank cheque" for a company that would compete with UTE in generation. No environmental application for the project has been publicly reported since.[288]

Finally, on a longer horizon, MIEM has authorized ANCAP to bid for offshore wind blocks for hydrogen production: Uruguay has identified more than twenty blocks, of which four (~500 km²) are to be tendered, with a potential of up to ~3 GW of offshore wind and ~200 kt of hydrogen per year; this remains an exploratory, long-term prospect with multi-year work plans.[289]

Taken together, a strong export orientation primarily towards the EU in the form of e-methanol and e-fuels is visible, considering the different production volumes. Almost all of the projects depend on new dedicated renewable parks rather than on grid electricity, reflecting the interplay with the resource base described in Chapter 4.1. The gap between a small operational segment and megaprojects not yet past their final investment decision underlines that Uruguay's export ambition is real but, as yet, unmaterialized.

4.4. Socially relevant dimensions for hydrogen development for Uruguay

Chapter 3.4 introduced four clusters of social dimensions as possible dimensions of social sustainability in hydrogen certification: water use and access, land use and land rights, labor standards, and community engagement, transparency and grievance mechanisms. These were derived from the IFC Performance Standards and the emerging literature on hydrogen justice. What dimensions are in fact relevant for a given producer country is, however, a question that cannot be answered at the level of general frameworks. The purpose of this section is therefore to test each cluster against the Uruguayan context and to establish which of them qualify as critical for the certification pathway.

The starting point is a baseline profile that distinguishes Uruguay from most other prospective hydrogen exporters in the region. The country combines political and social stability. Land access is regulated by the state, environmental and territorial authorization procedures are consolidated, and labor institutions are robust.[290] The analytical consequence is twofold: First,

[288] Búsqueda (2024), reporting the board decision, the routine characterization by a UTE source and Cardona's statement on X; also reported by Canal 9 Telerocha (2024b).
[289] Cf. Green Hydrogen Organisation (n.d.).
[290] Cf. AHK Uruguay/GIZ H2Uppp (2025), pp. 7 f. and 13.

Uruguay is not a high-baseline-risk context in the sense of the extractive development patterns discussed in Chapter 3.4. Second, the technical and emissions-related hurdles are comparatively low, as developed in Chapter 2.4.

Measured in aggregate volumes, water is not a scarce input for hydrogen production in Uruguay. Electrolysis consumes approximately 9 to 11 liters of water per kilogram of hydrogen, rising to roughly 45 liters, once cooling and auxiliary services are included.[291] The projected water demand of the entire Roadmap portfolio to 2040, at roughly 35 million m³ per year, corresponds to about 1 % of the volume authorized for agricultural irrigation and 6 % of that authorized for industrial use in 2022, measured against the abstraction rights granted by the national water directorate DINAGUA.[292] Aggregate figures of this kind, however, conceal the distribution that matters. A technical assessment commissioned by MIEM and carried out by the Institute of Fluid Mechanics and Environmental Engineering of the Universidad de la República found that while the demand is negligible at national scale, several internal basins are already under high pressure during low-flow summer periods, so that new direct abstractions from natural watercourses are constrained there — for hydrogen production as for any other water-using industry.[293] The social importance of water, however, is decoupled from these volumes, for reasons specific to the Uruguayan context. Access to drinking water and sanitation has held the status of a fundamental human right under Article 47 of the Constitution since the 2004 constitutional plebiscite, giving water a constitutional and political weight.[294] Public attentiveness to water issues increased significantly following the 2023 drought, the worst since 1947, which brought the Paso Severino reservoir below 2 % of its capacity and led to the declaration of a water emergency for the metropolitan area of Montevideo on 19 June 2023.[295] The episode has heightened public sensitivity to any large-scale water use, including by the hydrogen sector, independent of the sector's actual demand volumes; empirical perception data confirm that this sensitivity attaches to hydrogen specifically: in a national opinion study, 13 % of respondents spontaneously associated renewable hydrogen with water and natural resource use, against the backdrop of only 40 % having heard of the technology at all.[296] A survey conducted by the Universidad de la República among residents in the area of influence of the Tambor project found that, once

[291] Cf. AHK Uruguay/GIZ H2Uppp (2025), p. 12, citing IEA (2019).
[292] Cf. MIEM (n.d. a).
[293] Cf. MIEM (2025a).
[294] Constitution of the Oriental Republic of Uruguay, Art. 47.
[295] Cf. Mongabay Latam (2023); Infobae (2023).
[296] Improfit (2023) for the H2U communication strategy, cited in: Universidad Católica del Uruguay (2024).

informed, respondents' principal concerns were the quantity and origin of the water to be used and the project's impact on other water uses, alongside the characteristics of the jobs created.[297]

That these concerns translate into concrete regulatory and political friction is visible in the two megaprojects described above. In the Tambor procedure, water consumption per kilogram of hydrogen and methanol became a central point. In the HIF Paysandú case, the water dimension is reflected by the Ministry's terms of reference, which require the operator to produce hydrological descriptions of the Río Uruguay covering drought and flood conditions at the points of water intake and discharge.[298] It has also acquired a transboundary character, as the Argentine city of Colón, situated opposite the project site on the river governed by the binational commission CARU, has been incorporated into the area of the environmental impact assessment.[299] Water therefore qualifies as a critical dimension: social acceptance of hydrogen projects visibly turns on whether water use is perceived as transparent, measured and verifiable, a constellation in which verifiable water-use criteria and transparent monitoring supply precisely the assurance that aggregate statistics cannot provide. [300]

The land footprint of the Uruguayan project pipeline is substantial and is driven primarily by the dedicated renewable generation parks rather than by the production plants themselves. In the Tambor configuration a plant site of roughly 35 hectares is accompanied by approximately 500 hectares of solar and 2,300 hectares of wind installations. In the HIF case the industrial site as originally located comprises 440 hectares, subdivided after redesign into 180 hectares for industrial and logistical use and 260 hectares placed under an ecological servitude, with clearance of native forest reduced from 110 to 33 hectares; the solar park Lucía alone is projected across some 1,500 hectares to which the Elena wind park and roughly 160 kilometers of transmission lines must be added.[301] Taken together, the dedicated generation areas of the two projects amount to some 4,300 hectares, or 43 km², the equivalent of roughly six thousand full-size football pitches or almost twelve times the area of New York's Central Park. Uruguayan land governance is a mitigating factor, on paper, as access to land is state-regulated and legally secure, and the country records no unresolved large-scale land tenure conflicts.[302] Early project experience nonetheless shows that land use is contested. The

[297] Cf. Cátedra UNESCO de DDHH et al. (2024).
[298] Cf. Infobae (2026a).
[299] Cf. Infobae (2026a).
[300] Cf. Hartmann et al. (2023), section 3.2 (attribute list).
[301] Cf. Ministerio de Ambiente/OAN (n.d. b) and (n.d. c); El Observador (2025c); El Observador (2025d).
[302] Cf. AHK Uruguay/GIZ H2Uppp (2025), p. 7.

recategorization of 100 hectares of land from rural-productive to suburban-industrial use for the Tambor plant was challenged before the Supreme Court of Justice in 2023 by residents organized in civil society groups (Red de Semillas Nativas y Criollas, Colectivo Agua es Vida).[303] The action was dismissed in March 2024, but documents nonetheless that land-use conversion for hydrogen is already an object for legal contestation.[304] In the HIF case, the operator was fined by the Ministry of Environment for clearing native forest without prior authorization.[305] Contestation has moreover moved beyond litigation to reshape the project itself. Objections from the Argentine province of Entre Ríos and the city of Colón, opposite the Constancia site across the Río Uruguay, combined with legal action by Entre Ríos legislators and organized local opposition, led the departmental and national authorities from April 2026 to pursue relocation of the plant some ten kilometers inland, to a 48-hectare site owned by ANCAP at Nuevo Paysandú that adjoins existing industrial installations, is already classified for industrial use, and requires neither recategorization nor clearance of native forest.[306] By August 2026 the relocation was reported as settled, although no formal announcement had been made; in the same month a local campaign submitted 17,201 signatures of registered voters to the departmental legislature seeking to prohibit the project in Paysandú altogether.[307] Some civil society organizations situate hydrogen and e-fuel projects within a longer debate about foreign investment in land-intensive export sectors, drawing parallels with earlier discussions around the forestry sector. This perspective, while contested, is politically salient and shapes the environment in which projects seek local acceptance.[308] This position is a political position and is cited here as such; it is nonetheless highly relevant because it shapes the public debate in which projects must earn local acceptance.

The indigenous-rights component of this cluster requires particular care, because the available sources diverge. Uruguay currently recognizes in its law neither indigenous peoples as distinct legal subjects nor indigenous territories, and accordingly provides no operative framework for Free, Prior and Informed Consent; the UN Committee on the Elimination of Racial Discrimination has addressed the recognition of indigenous peoples, their ancestral lands and prior consultation in both of its most recent reviews of Uruguay.[309] This picture is, however,

[303] Cf. Waiter/Cohanoff/Contreras (2025).
[304] Cf. Méndez (2024).
[305] Cf. Agencia Tierra Viva (2026).
[306] Cf. Ámbito (2026); Infobae (2026b).
[307] Cf. Análisis Digital (2026).
[308] Cf. Agencia Tierra Viva (2026); Coalition for Human Rights in Development (2025).
[309] Cf. Repetto Iribarne (2023), pp. 82 ff.; CERD/C/URY/CO/21-23, 17 January 2017 (prior and informed consent, land rights); CERD/C/URY/CO/24-26, 13 September 2023.

incomplete. In the 2011 census, approximately 5 % of the population, about 159,000 people, declared indigenous ancestry.[310] Organizations of Charrúa descendants (most prominently CONACHA) actively claim recognition, and Uruguay has not yet ratified ILO Convention 169 on Indigenous and Tribal Peoples, a step several of its regional peers have taken; this represents a regulatory gap rather than a policy failure.[311] Notably, the highest shares of indigenous ancestry are recorded in the north of the country, including Tacuarembó.[312] For a certification pathway benchmarked against IFC Performance Standard 7 and against the CertHiLAC attribute referring to neighboring communities and indigenous communities, this creates a verification problem. The absence of formal recognition means that international requirements have no domestic legal anchor, so that any credible safeguard would have to be defined at the level of the certification scheme itself. Land therefore qualifies as a critical dimension in various forms, such as land-use conversion, fragmentation, and the conflict-free-land requirement.

Uruguay's labor baseline is strong: occupational health and safety obligations are codified, particularly relevant to hydrogen as a chemical-risk industry, in Decree No. 307/009, trade unions are consolidated and active, and interviewed market actors describe a culture of regulatory compliance reinforced by judicial sanctions.[313] Three features of the hydrogen ramp-up nonetheless make labor a critical dimension. First, the ramp-up takes place in rural, low-density departments with above-average unemployment, where the influx of a large temporary construction workforce carries documented risks. The IDB's sectoral EH&S guidance identifies pressure on housing, health and other local services, community tensions, and gender-based violence as characteristics of large hydrogen developments in exactly such settings.[314] Uruguay's own precedent supports this concern, as an assessment prepared in connection with the second UPM pulp mill warned of the increased crime and sexual exploitation accompanying the construction phase.[315] Second, employment is strongly front-loaded: HIF Paysandú anticipates around 1,400 construction jobs against roughly 300 permanent positions, so that the durability and quality of employment determine whether the Roadmap's expectation translates into real social value. Third, local capacity to capture the

[310] Census figures per Instituto Nacional de Estadística (2011).
[311] Cf. Repetto Iribarne (2023); on the CONACHA demands cf. Consejo de la Nación Charrúa (n.d.); ratification status: ILO Convention No. 169.
[312] Cf. Ambienta (2024).
[313] Cf. AHK Uruguay/GIZ H2Uppp (2025), pp. 13 f.; Decree No. 307/009 of 3 July 2009.
[314] Cf. Signoria/Barlettani (2023).
[315] Cf. El Observador (2018).

permanent positions is limited. The departments record educational profiles below the national average: persons aged 25 and over have completed on average nine years of schooling nationally against eleven in Montevideo, and in Paysandú the share of the employed whose highest attainment is university level falls below the national figure, alongside an employment rate of 53.6 % against 57.7 % nationally.[316] This matters less as a measure of deprivation than as a constraint on the benefit the sector is expected to deliver. HIF projects that roughly 70 % of its workforce will be recruited locally, yet studies commissioned by MIEM and the Ministry of Labor document a structural shortage of technicians qualified for electrolyzer operation, renewable integration and export infrastructure, with existing training provision not yet covering the required competences.[317] Absent deliberate qualification programmes, the foreseeable distribution is that permanent skilled positions are filled by workers brought in from outside the department while local participation concentrates in temporary construction work, sharpening both the influx risks and the distributional question of who benefits.[318] This is precisely the divergence between employment generation and social value identified in Chapter 3.4. The gender dimension cuts across all three points, as structural barriers to women's participation in technical energy employment persist, and worker-influx settings carry specific risks for women.[319] Labor therefore qualifies as critical because of the attributes that matter in Uruguay: quality, locality, durability and inclusiveness of employment.

Uruguay's formal participation framework is comparatively dense. Environmental impact assessment under Law No. 16.466 (1994) and Decree No. 349/005 requires public hearings for high-impact projects, the category into which medium- and large-scale hydrogen projects are expected to fall.[320] The territorial planning regime under Law No. 18.308 (2008) mandates early publication and involvement of departmental authorities.[321] Cooperation agreements between MIEM and the departments of Paysandú and Tacuarembó add information and capacity-building measures at the two megaproject sites.[322] The Strategic Environmental Assessment of the hydrogen value chain, under way since September 2025, extends this architecture for the first time to the sectoral level, with participatory workshops explicitly

[316] Cf. Observatorio Territorio Uruguay (n.d.); ANDE (n.d.).
[317] Cf. MIEM/MTSS (2025); Signoria/Barlettani (2023), section 8.10; AUDER (n.d.).
[318] Cf. Signoria/Barlettani (2023), section 8.10; AUDER (n.d.).
[319] Cf. Signoria/Barlettani (2023), section 8.10.
[320] Law No. 16.466 of 26 January 1994; Decree No. 349/005 of 3 October 2005.
[321] Law No. 18.308 of 30 June 2008.
[322] Cf. MIEM (2025c); MIEM (2024).

designed to capture the perspectives of potentially affected communities.[323] The framework is reinforced by international commitment. Uruguay approved the Escazú Agreement by Law No. 19.773 of 17 July 2019, before its entry into force in April 2021, and has gone further than most parties in operationalizing it: the national implementation roadmap, together with the objectives and priority actions of the National Plan for the Implementation of Access Rights in Environmental Matters, was adopted by Ministerial Resolution No. 1.224/024 of 5 November 2024 and presented publicly that month, ahead of the deadline of 2026 set by the third Conference of the Parties. Uruguay held the Presidency of the Conference of the Parties, exercising it through the fourth meeting in Nassau in April 2026, at which the chair passed to Saint Kitts and Nevis.[324] Records nonetheless document a gap between formal provision and effective participation. The available records concern who was convened rather than whose views prevailed. The strategic environmental assessment documents its instances separately by actor group — an inter-institutional workshop in September 2025, sessions with organized civil society, academia and the private sector in the following weeks, and territorial sessions in Tacuarembó and Paysandú in March 2026 — and publishes minutes for them.[325] The Paysandú session is the one instance for which a shortfall is documented, and the reported complaint concerned the format rather than the composition: attendees interrupted the presentations to demand changes in methodology and more time for questions, and observers described a gap between the institutional design of the exercise and the expectations of those present.[326] Whether the views of residents were displaced by those of organized advocacy is not recorded, and no source consulted permits that assessment. What can be observed is that the two instruments capturing local views without intermediaries, the Universidad de la República survey in the Tambor area of influence and the signature campaign in Paysandú, register concerns of the same kind, over water, the quality of employment, and siting. Peer-reviewed actor analysis finds that public hearings are non-binding, that linkages between the state, the productive sector and civil society remain weak for example, even academic actors were involved only at the final stage of the Roadmap's elaboration.[327] The Udelar survey cited above records a demand among residents for more and better information about the projects, and the first open EAE sessions in Paysandú in early 2026 were themselves marked by friction

[323] Cf. Ministerio de Ambiente/OAN (n.d. a); Ministerio de Ambiente/OAN (2025b).
[324] Law No. 19.773 of 17 July 2019; Resolution No. 1.224/024 (Ministerio de Ambiente); cf. CEPAL (2024); Ministerio de Ambiente (2026).
[325] Cf. Ministerio de Ambiente/OAN (n.d. a); Ministerio de Ambiente/OAN (2025b).
[326] Cf. El Telégrafo (2026).
[327] Cf. Waiter/Cohanoff/Contreras (2025).

between officials and attending citizens.[328] The Botnia/UPM pulp mill dispute of 2004–2010, in which the ICJ found that Uruguay had not complied with its procedural obligations to inform and consult Argentina through the binational commission CARU while dismissing the substantive claims, remains a significant historical reference for transboundary community relations in the region.[329] Current developments around HIF Paysandú, including the relocation requests raised by Argentine authorities, indicate that cross-border engagement mechanisms of this kind warrant early attention.[330] Finally, the Uruguayan framework concentrates participation in the authorization stage, interviewed actors emphasize that sustaining acceptance requires permanent channels of exchange beyond the public hearing, which is precisely the function that lifecycle-wide grievance mechanisms in the sense of IFC Performance Standard 1 would institutionalize but which no general legal requirement currently mandates.[331] The procedural dimension of community engagement, transparency and accessible grievance mechanisms therefore qualifies as critical, because it is where formal compliance and social legitimacy diverge most visibly in Uruguay.

The assessment confirms all four clusters introduced in Chapter 3.4. as relevant for Uruguay, but with a country-specific profile. Uruguay's critical social risks are not rooted in absolute water scarcity, unresolved land tenure, or weak labor law. They are, in essence, risks of perception and procedure: heightened public sensitivity to water use in the aftermath of a constitutionalized right and the 2023 drought; the conversion and fragmentation of rural land through procedurally contested channels, compounded by an unresolved recognition question regarding indigenous descendants; the quality, durability and locality of employment rather than its quantity; and the effectiveness, bindingness and continuity of participation beyond formal hearings.

5. Gap Analysis EU RFNBO – CertHiLAC

5.1. Comparison Framework and Reference Points

This chapter is deliberately confined to the social dimension. The technical and regulatory RFNBO criteria are not compared here in their own right. They were established in Chapter 3.5.2. and their treatment in CertHiLAC's "H2 Certification for EU Markets" category in Chapter 3.6.4., and the conclusion following those two sections is taken here as premise. That premise

[328] Cf. Cátedra UNESCO de DDHH et al. (2024); El Telégrafo (2026).
[329] ICJ, Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgment of 20 April 2010.
[330] Cf. Agencia Tierra Viva (2026).
[331] Cf. AHK Uruguay/GIZ H2Uppp (2025), p. 11; IFC (2012), Performance Standard 1, as introduced in Chapter 3.4.

is threefold: The EU-market category was designed to mirror the RFNBO criteria and is substantively aligned with them, including in its recommendation of a mass-balance chain of custody.[332] CertHiLAC has not yet obtained Commission recognition, therefore has no access to the Union Database, and cannot issue a Proof of Sustainability.[333] The IDB guide accordingly recommends that, for the time being, producers seeking access to the European market certify under a scheme recognized by the Commission and use CertHiLAC alongside it for domestic and regional purposes.[334] Of these two tracks, the first has since been shown to work for a Latin American producer: HIF's Haru Oni facility in Chile obtained ISCC EU RFNBO certification in 2025 and renewed it in 2026, as set out in Chapter 4.3. The second remains untested, no certificate having yet been issued under CertHiLAC. For any near-term Uruguayan project the technical compliance question is therefore already answered by the recognized-scheme route, irrespective of CertHiLAC's consolidation. It is the social dimension that neither route resolves.

The first object of comparison is the EU RFNBO framework as established in Chapter 3.5. For the purpose of this analysis, it comprises the Renewable Energy Directive as revised by Directive (EU) 2023/2413, Delegated Regulations (EU) 2023/1184, as aligned terminologically with the revised Directive by Delegated Regulation (EU) 2024/1408, and (EU) 2023/1185, and Implementing Regulation (EU) 2022/996.[335] As established, it is binding law, therefore its requirements are not aspirational attributes but cumulative conditions of RFNBO eligibility and by Article 1 of Delegated Regulation (EU) 2023/1184 its rules apply irrespective of whether the fuel is produced inside or outside the Union.[336]

The second is CertHiLAC as proposed in the IDB implementation guide of 2023, read together with the implementation status documented in the OLADE Technical Note of 2025.[337]

Two asymmetries follow from this pairing and shape how the results are to be read. The comparison sets binding law against a voluntary design proposal that has not yet issued a certificate, so that divergences identified on the CertHiLAC side are design-stage divergences rather than operational failures. What the comparison identifies is not primarily what one lacks

[332] Cf. Hartmann et al. (2023), p. 20.
[333] Cf. Hartmann et al. (2023), p. 22.
[334] Cf. Hartmann et al. (2023), p. 22.
[335] Directive (EU) 2023/2413; Delegated Regulation (EU) 2023/1184; Delegated Regulation (EU) 2023/1185; Delegated Regulation (EU) 2024/1408; Implementing Regulation (EU) 2022/996.
[336] Delegated Regulation (EU) 2023/1184, Art. 1.
[337] Cf. Hartmann et al. (2023); OLADE (2025).

relative to the other, but what both may lack relative to the risk profile established in Chapter 4.4.

Another preliminary clarification concerns the voluntary schemes recognized by the Commission on 19 December 2024 (ISCC EU, CertifHy and REDcert-EU), which, as established in Chapter 3.5.3, constitute the operative certification route through which RFNBO compliance is evidenced in practice.[338] It could be argued that these schemes, rather than the regulation itself, form the more realistic comparator for CertHiLAC, particularly since voluntary schemes have historically added social requirements beyond the EU baseline in the biofuels sector.[339] An examination of the certification documents of the three schemes recognized by implementing decision shows that this has not materialized for RFNBOs, contrary to expectations documented in the advisory literature prior to recognition, which anticipated that the extension of ISCC EU to RFNBOs would address criteria such as social impact and water consumption.[340] The RSB standard is the exception, since it requires electrolysis producers to comply with the full RSB Principles and Criteria including their social principles (Chapter 3.1); it is not used as the benchmark here because it certifies in the interim status described in Chapter 3.5.3 and because the operative route for the Uruguayan flagship project runs through ISCC EU.[341] ISCC EU lays down its certification requirements for RFNBOs in two System Documents.[342] These operationalize the electricity-sourcing rules, the greenhouse gas methodology and the chain of custody of the EU framework.[343] The scheme's broader sustainability principles, by contrast, including its social requirements on human, labor and land rights, are codified in the system documents governing agricultural biomass, where they constitute ISCC's voluntary addition (Principles 2–6) to the land-related baseline of Article 29, which alone is mandatory under the Directive (Principle 1).[344] They attach to the point of origin of the biomass, therefore forming no part of the RFNBO supply chain scope, which begins at the hydrogen producer, with the renewable electricity producer providing only a self-declaration.[345] One qualification applies, and it is not hypothetical for the Uruguayan case. Although biomass is by definition excluded from the energy content of an RFNBO, the e-fuels

[338] Implementing Decisions (EU) 2024/3176 (ISCC EU), (EU) 2024/3180 (CertifHy) and (EU) 2024/3194 (REDcert-EU), all of 19 December 2024.
[339] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), p. 151.
[340] Cf. Tietze/Tsoumpa/Ullrich (2024), p. 24.
[341] Cf. RSB (2025b)
[342] ISCC EU 202-6; ISCC EU 205-1.
[343] ISCC EU 202-6; ISCC EU 205-1.
[344] ISCC EU 202-1, Version 4.2, ch. 1–2 (Principle 1 as implementation of Art. 29(2)–(5) of the Directive, mandatory under RED III); ISCC EU 202-2 (Principles 2–6).
[345] ISCC EU 202-6.

of both national megaprojects are synthesized from renewable hydrogen and biogenic CO_2 — sourced from ALUR's bioethanol plant in the case of HIF Paysandú and from the biomass boiler of the Dank plant in Tranqueras in the case of Tambor. The eligibility of a biogenic carbon source is governed not by the RFNBO definition but by the emissions methodology, which makes it conditional on the CO_2 deriving from biomass that itself complies with the sustainability criteria of Article 29.[346] The biomass sustainability regime therefore re-enters the pathway at the point of origin of the CO_2 rather than of the hydrogen. That this node is certifiable in principle is indicated by the ISCC EU RFNBO certification of Haru Oni, which likewise operates on biogenic CO_2. Since Article 29 criteria are exclusively environmental, however, this re-entry introduces no social requirement into the chain.

The comparison proceeds along the four clusters of social dimensions introduced in Chapter 3.4 and confirmed as critical for Uruguay in Chapter 4.4. For each, two questions are asked separately. The first concerns normative status: is the dimension mandatory, provided for as a reportable attribute, or absent? The second concerns operationalization: is there a defined indicator, threshold, evidence requirement or audit protocol by which compliance could be verified? Separating the two is essential, because a criterion that is named but not measurable produces a different kind of gap from one that is not named at all. The results of this assessment are summarized in Table 3 at the end of Chapter 5.2.

5.2. The Four Social Dimensions in Comparison

Water use and access: On the EU side the dimension is absent. Neither Article 29a of the Directive, which subjects RFNBOs to the greenhouse gas criterion alone, nor the delegated acts, nor the implementing regulation conditions RFNBO status on water use, water rights or competing local uses.[347] CertHiLAC addresses the dimension through two of its LAC-specific attributes: sources and sustainable use of water, and wastewater treatment with particular reference to brine disposal from desalination processes where applicable.[348] No indicator, reference value or evidence standard is specified for either, and the formal definition of the

[346] Delegated Regulation (EU) 2023/1185, Annex, point 10(c). For the CO_2 sources of HIF Paysandú and Tambor see Chapter 4.3; for Haru Oni operating on biogenic CO_2 and holding ISCC EU RFNBO certification cf. HIF Global (n.d. b).
[347] Directive (EU) 2018/2001 as amended by Directive (EU) 2023/2413, Art. 29a; Delegated Regulations (EU) 2023/1184 and (EU) 2023/1185; Implementing Regulation (EU) 2022/996.
[348] Cf. Hartmann et al. (2023), p. 17.

system's attributes and characteristics is listed as a pending task under Step 1 of the guide's implementation plan.[349]

Land use and land rights: The EU position here is doubly absent, because RFNBOs are subject to no land criterion of any kind, social or environmental. The extensive land-related criteria that Article 29 (3)-(5) of the Directive does impose apply to biomass, but are in any event exclusively environmental, containing no provision on land rights, displacement or consent.[350] CertHiLAC addresses the dimension through the attribute on location and use of socially and environmentally harmonious land, explicitly excluding land conflict areas, and, as regards affected populations, through the attribute on positive social impact on neighboring communities and indigenous peoples.[351] The conflict-area exclusion is notable as the closest the attribute set comes to a binary test. The guide does not, however, define what constitutes a land conflict area, who determines it, or against what evidence. For the communities and indigenous peoples attribute the guide is explicit that compliance requires at a minimum a community consultation, while stating that the final methodology for measuring the attribute must still be validated by the System Representative.[352]

Labor standards and decent work: The EU framework contains no labor requirement for RFNBOs; as with land rights, ILO conventions appear only as an object of the Commission's reporting duty in respect of biofuels.[353] CertHiLAC provides for the dimension through the attribute on compliance with international labor standards.[354] This is the most conventional of the LAC-specific attributes and the one whose reference framework is most readily identifiable. The relevant core is the ILO Declaration on Fundamental Principles and Rights at Work, amended in June 2022 to add a fifth category — a safe and healthy working environment — and with it Conventions No. 155 (1981) and No. 187 (2006) to the eight previously recognised as fundamental.[355] The amendment is material here, since hydrogen and its derivatives are high-hazard process industries. Uruguay has ratified all ten: Convention No. 155 by Law No. 15.965 of 1988, from which the tripartite National Council on Occupational Safety and Health derives, and Convention No. 187 by Law No. 20.354 of 19 September 2024, an act by which,

[349] Cf. Hartmann et al. (2023), section 4.1.7.
[350] Directive (EU) 2018/2001 as amended, Art. 29(3)–(5) and Art. 29a.
[351] Cf. Hartmann et al. (2023), p. 17.
[352] Cf. Hartmann et al. (2023), p. 16.
[353] Directive (EU) 2018/2001 as amended, Art. 29(3)–(5) and Art. 29a.
[354] Cf. Hartmann et al. (2023), p. 17.
[355] ILO Resolution of June 2022 (International Labour Conference, 110th Session) on the inclusion of a safe and healthy working environment in the ILO's framework of fundamental principles and rights at work; cf. ILO (n.d.).

on the Ministry of Labor's own account, the country completed the incorporation of the full set of fundamental principles into its legal order.[356] Beyond these, Uruguay has ratified 110 ILO instruments, including Convention No. 167 on safety and health in construction, the phase in which the workforce peaks, while Convention No. 169 remains unratified as noted above.[357] That completeness is what limits the attribute's force. ILO conventions bind states, not operators. Where the national baseline already incorporates the entire set, a requirement of "compliance with international labor standards" is discharged by operating lawfully and adds nothing the law does not already demand.

Community engagement, transparency and grievance mechanisms: The EU framework addresses the procedural dimension, but at a different level. Under Article 30(4) of the Directive the Commission may recognise voluntary schemes, and Implementing Regulation (EU) 2022/996 sets out the conditions such a scheme must satisfy, among them the maintenance of a complaints procedure and defined transparency obligations.[358] The term "voluntary" describes the category rather than the status of the obligations: participation in a scheme is voluntary for economic operators, but a scheme seeking recognition must demonstrate compliance with these conditions, and the Commission may withdraw recognition where it fails to do so. The requirements are therefore binding — but they are owed by the scheme as an institution. They establish no entitlement for a community affected by a production project to be informed, consulted or heard, and impose no obligation on the producer to provide a channel for grievance. CertHiLAC covers the dimension through the community consultation floor attached to the neighboring-communities attribute, which is the single most concrete procedural requirement in the entire attribute set.[359]

[356] Law No. 15.965 of 28 June 1988; Law No. 20.354 of 19 September 2024; cf. MTSS (n.d. a).
[357] Cf. MTSS (n.d. b).
[358] Implementing Regulation (EU) 2022/996, Art. 3.
[359] Cf. Hartmann et al. (2023), p. 16.

Table 3: Social dimensions in the EU RFNBO framework and CertHiLAC (own compilation)

SOCIAL DIMENSION	EU RFNBO FRAMEWORK	CERTHILAC ATTRIBUTE	OPERATIONALIZATION	RESULTING GAP
Water use and access	**Absent.** Reporting template exists for biomass only	Sources and sustainable use of water; wastewater / brine treatment	No indicator, threshold or evidence standard; attribute definition still pending (Step 1)	**Substantive** (EU) **Operative**
Land use and land rights	**Absent.** Land criteria for biomass are exclusively environmental	Socially and environmentally harmonious land, excl. conflict areas; positive social impact on neighboring communities / indigenous peoples	"Conflict area" undefined; consultation floor set, measurement methodology deferred to System Representative	**Substantive** (EU) **Operative** **Calibration**
Labor standards and decent work	**Absent.** ILO conventions appear only in a biennial Commission report on biofuel-supplying countries	Compliance with international labor standards	Reference framework identifiable; no audit protocol defined	**Substantive** (EU) **Calibration**
Community engagement, transparency, grievance	**Scheme-level only** (Art. 3 IR 2022/996); no producer duty toward communities	Covered indirectly via the neighboring-communities attribute	Minimum of one community consultation; no lifecycle grievance mechanism	**Substantive** (EU) **Operative** **Calibration**

Substantive — EU side: the dimension is not reflected in the RFNBO framework in any form binding on a producer.
Operative — CertHiLAC side: the dimension is named but carries no indicator, threshold or evidence standard an auditor could apply.
Calibration — the attribute is derived from a regional LAC average rather than the Uruguayan form of the risk.

5.3. Synthesis: Types of Gaps

The comparison summarized in Table 3 yields three deficits, which differ in kind and therefore call for different responses.

The first is a substantive gap, located on the EU side. None of the four dimensions is reflected in the RFNBO framework in any form binding on a producer. The schemes through which RFNBO compliance is evidenced largely mirror this scope; among the recognized-route schemes, only the RSB standard adds mandatory social criteria at scheme level (Chapters 3.1 and 5.1). The absence is a matter of scope rather than of drafting, since the Directive contains functioning templates for social and water-related reporting but confines them to biomass. A note on scope is warranted at this point, since the biomass regime is the one part of the Directive that does contain social and water-related provisions. It is not pursued further here for a reason of scope rather than of relevance. The RFNBO supply chain begins with the

hydrogen producer, whereas the biomass sustainability criteria attach to the origin of the feedstock. They re-enter the pathway of a Uruguayan project only through the carbon source, as set out in Chapter 5.1, and what they impose there, binds the operator in respect of land, forest and carbon stock alone. Examining them in greater depth would establish where the biomass regime applies, not whether it supplies a social requirement. The Uruguayan case sharpens the point rather than softening it. The carbon for both megaprojects derives in part from the combustion of forestry residues, so that the regime attaching to that feedstock reaches into precisely the sector whose social consequences, land concentration and the terms of employment in the forestry-cellulose complex, civil society invokes when it frames hydrogen as an extension of that model, as recorded in Chapter 4.4. The Directive governs that node for soil, biodiversity and carbon stock; the social aspects of that node lie outside its criteria.

The second is an operative gap located on the CertHiLAC side. All four dimensions are addressed, and the attribute set is, in its coverage, considerably closer to the risk profile of a hydrogen producer. What is missing is the apparatus that would turn coverage into verification: no indicators, no reference values, no evidence requirements and no audit protocols are specified for any social attribute, except for the consultation floor, and the definition of the attributes itself is still a pending implementation task.[360] This gap is a function of the development stage, and it is in principle closable by the System Representative.

The third is a calibration gap, referring to CertHiLAC's LAC-specific attributes being derived from a regional analysis of risks and impacts across Latin America and the Caribbean.[361] The resulting set is calibrated to a regional risk average: weak labor-law enforcement, unresolved land tenure conflict, coastal desalination configurations, and formally constituted indigenous territories. As established, Uruguay's risk profile diverges from that average, considering that its critical risks might lie more in perception and procedure. The presence of an attribute in a regional system therefore does not establish that the corresponding national risk is fully covered. It is not that the regional system is insufficiently ambitious, but that a harmonized regional attribute set cannot by construction be calibrated to the risk profile of any individual member state.

The gaps identified are gaps in the certification frameworks, not necessarily in the regulatory coverage of the dimensions in absolute terms. As established previously, Uruguayan law

[360] Cf. Hartmann et al. (2023), p. 16.
[361] Cf. Hartmann et al. (2023), p. 18.

addresses parts of each dimension: environmental impact assessment and public hearings under Law No. 16.466 and Decree No. 349/005, territorial planning under Law No. 18.308, occupational health and safety under Decree No. 307/009.[362] What is absent is not regulation of these matters as such, but their integration into the instrument that determines market access and travels with the product. A safeguards module therefore has to be designed against the existing national baseline rather than in place of it, and its function is to make verifiable, in a form legible to an export market, conditions that are partly regulated already but nowhere certified.

6. Conceptual Certification Pathway for Uruguay

6.1. From Gap Analysis to design requirements

The preceding chapters have established, in sequence, the premises on which a certification pathway for Uruguay can be constructed. Chapter 3 set out the binding requirements of the EU RFNBO framework and the design of the regional CertHiLAC system; Chapter 4 established Uruguay's institutional, project and social context; and Chapter 5 identified, along four socially critical dimensions, what the two frameworks require of a producer and what neither of them requires. This chapter turns from analysis to design and thereby answers the third sub-question of this thesis: how a certification pathway for Uruguay can be designed to bridge the identified gaps and operationalize EU RFNBO compliance while ensuring credible and verifiable social safeguards for the most critical social risks in Uruguay.

A design that responds to the gap analysis must take its three results seriously as three different kinds of problem. The substantive gap means that no social requirement can be expected to arrive through the EU market-access rules themselves — a restriction that the schemes recognized by implementing decision mirror for RFNBOs, with RSB as the scheme-level exception, and that the EU framework maintains not least for reasons of WTO compatibility (Chapters 3.1, 3.5.5 and 5.1). The operative gap means that CertHiLAC's coverage of the social dimensions still lacks the apparatus of verification, whose definition remains a pending implementation task.[363] The calibration gap means that a harmonized regional attribute set cannot by construction capture the specifically Uruguayan form of the risks, which lie in perception and procedure rather than in absolute scarcity or weak law (Chapters 4.4 and 5.3).

[362] Law No. 16.466; Decree No. 349/005; Law No. 18.308; Decree No. 307/009; see Chapter 4.4.
[363] Cf. Hartmann et al. (2023), p. 16; on the pending attribute definition ibid., section 4.1.7; see Chapter 5.3.

Three further findings frame the design space. First, the technical compliance question is for practical purposes already answered by the recognized-scheme route, proven by the operator of Uruguay's own flagship project (Chapters 4.3 and 5.1): the pathway does not need to create EU market access, but to organize it and to add what the existing route does not deliver. Second, the gaps identified are gaps in the certification frameworks, not in Uruguayan regulation as such; what is missing is the integration of conditions national law partly governs already into an instrument that determines credibility in the export market and travels with the product (Chapter 5.3). Third, the introduction identified two distinct audiences — market credibility owed to the export market, social legitimacy owed to the producing context — and left open whether both are best served by a single EU-aligned certification or by a complementary, locally oriented layer. The gap analysis has effectively decided this: since the EU-aligned route carries no social content for RFNBOs and cannot be expected to acquire it, a single instrument cannot serve both audiences. The design consequence is the deliberately two-part architecture developed below; the fuller argument is returned to in Chapter 7.

From these findings, six design requirements are derived. They function in the remainder of this chapter as the standard against which every element of the pathway is justified; Table 4 traces each requirement to the finding from which it derives and to the pathway element that implements it.

R1 — Recognized-scheme eligibility as the non-negotiable core. EU market eligibility must run through certification under a Commission-recognized voluntary scheme, since only such certification permits the issuance of a Proof of Sustainability and entry into the Union Database (Chapters 3.5.3 and 3.5.4). Nothing in the additional social layer may interfere with, condition, or delay this core.

R2 — Additive and voluntary character of the social layer. Because the EU framework offers no legal anchor for social criteria in RFNBO eligibility, and because process-based social conditions attached to market access raise the trade-law difficulties set out in Chapter 3.5.5, the social layer must be constructed as a voluntary, additive instrument whose claims stand beside, not inside, the RFNBO claim.

R3 — Verifiability first. Every social criterion must be specified to the level at which an auditor can verify it: a defined indicator, a defined evidence base, and a defined verification protocol. This requirement responds directly to the operative gap; a module that named dimensions without operationalizing them would reproduce the very deficit identified in Chapter 5.

R4 — Calibration to the Uruguayan risk profile. The module's criteria must address the country-specific form in which each dimension is critical in Uruguay, as established in Chapter 4.4 and mapped in Table 10 below, rather than the regional average form from which CertHiLAC's attributes were derived.

R5 — Building on the national baseline, not beside it. Uruguayan law already produces much of the evidence a social certification would need (Chapters 4.2 and 4.4). The module must be designed to certify against this baseline, reusing the evidence the legal process already generates, rather than duplicating procedures and burdening projects and communities twice.

R6 — Scheme-agnostic docking. The module must be able to attach to more than one host. In the near term it must be auditable alongside the recognized-scheme certification a producer needs anyway; in the medium term it must be capable of serving as Uruguay's national specification of CertHiLAC's LAC-specific social attributes, whose formal definition is still pending under Step 1 of the implementation plan.[364] Designing the module scheme-agnostically ensures that it neither depends on CertHiLAC's consolidation nor forecloses it — and that it converts the calibration gap from a deficiency into a contribution, by feeding a nationally calibrated operationalization back into the regional process.

Table 4: From the findings of Chapters 3–5 to the design requirements of the pathway (own compilation)

FINDING (chapter)	DESIGN REQUIREMENT	PATHWAY ELEMENT (section)
Recognized-scheme route proven and required for EU access (4.3, 5.1)	R1 **Recognized-scheme core, untouched**	Track 1 (6.2.1)
Substantive gap: no social content in EU route; WTO constraints (3.5.5, 5.2)	R2 **Voluntary, additive social layer**	Track 2 (6.2.2)
Operative gap: no verification apparatus for social attributes (5.2, 5.3)	R3 **Indicator – evidence – verification for every criterion**	Module design (6.3)
Calibration gap: regional average vs. Uruguayan risk profile (4.4, 5.3)	R4 **Criteria address the Uruguayan form of each risk**	Safeguard areas SM1–SM4 (6.3.2–6.3.5)
National law regulates but does not certify (4.2, 5.3)	R5 **Certify against the national baseline, reuse legal-process evidence**	Evidence bases (6.3); implementation (6.4)
Dual audience; CertHiLAC attribute definition pending (1.1, 3.6.5)	R6 **Scheme-agnostic module, capable of regional feed-in**	Docking options (6.2.2); Phase 3 (6.4.2)

[364] Cf. Hartmann et al. (2023), p. 37.

6.2. Architecture of the pathway

The pathway proposed here consists of two tracks that a Uruguayan export project would pursue in parallel: a compliance track, through which RFNBO eligibility is evidenced under a Commission-recognized scheme, and a safeguards track, through which the project's social performance is made verifiable through the Social Safeguards Module. The two tracks are deliberately asymmetric in legal character, in that the first is dictated by binding EU law while the second is a voluntary instrument of Uruguayan design, and deliberately symmetric in assurance logic, both resting on third-party audit by accredited certification bodies. Their separation implements R1 and R2; their coordination, developed in Section 6.2.3, implements R5.

6.2.1. Track 1: Evidencing RFNBO eligibility through a recognized scheme

The first track requires no new institution and is described here only to the extent necessary to define what the second track must and must not do. A Uruguayan producer targeting the EU market certifies under one of the schemes recognized for RFNBO purposes (Chapter 3.5.3); for the Uruguayan flagship configuration, ISCC EU is the empirically proven route, held and renewed by the operator of the Paysandú project for its Chilean facility across the full value chain (Chapter 4.3).

In the configurations actually planned, the electricity-sourcing criterion is met through dedicated renewable parks connected under arrangements satisfying additionality and temporal and geographical correlation (Chapters 3.5.2 and 4.3). One point follows from Uruguay's specific grid profile and is worth making explicit. With an emission factor of 1.74 gCO_2/MJ in 2024 and 3.37 gCO_2/MJ in 2025, Uruguay's grid lies far below the threshold of 18 gCO_2eq/MJ at which Delegated Regulation (EU) 2023/1184 counts grid electricity as fully renewable on the basis of a PPA with temporal and geographical correlation but without the additionality requirement, and its renewable share exceeded in both years the 90 % benchmark at which grid electricity counts as fully renewable without a PPA (Chapters 3.5.2 and 4.1).[365] Uruguay is thus one of the few prospective exporters for which the grid routes are realistically available at all. The same data, however, show their dependence on hydrology: in the drought year 2023 the renewable share fell to approximately 88.5 %, below the 90 % benchmark, while the emission factor of 15.6 gCO_2/MJ remained under the intensity threshold only with a narrow margin, and in 2021 it exceeded it at 28.0 gCO_2/MJ (Chapter 4.1). The

[365] Delegated Regulation (EU) 2023/1184, Art. 4(1) and (2).

Regulation dampens this variability, since a share above 90 % or an intensity below 18 gCO_2eq/MJ reached in one calendar year is deemed to persist for the subsequent five calendar years, so that the 2024 values would carry eligibility under both grid routes through 2029 even if hydrology deteriorated. Over the lifetime of an export plant, however, the grid routes rest on a status that has to be renewed against a hydrologically volatile record and, under the 90 % route, on a cap on production hours tied to the renewable share; above all, they presuppose a system that can spare the electricity, whereas a single 1 GW electrolyzer at high utilization would draw a volume in the order of one third to one half of the roughly 14.5 TWh delivered to the national grid in 2024 (author's estimate on the basis of the BEN generation data). The pathway therefore treats the dedicated-park-plus-PPA configuration as the robust default, with the grid routes as supplementary flexibility, for instance for commissioning phases, which also preserves the additionality logic under which the sector's demand is met by newly built capacity rather than by claims on the existing renewable system.[366]

The greenhouse gas criterion is structurally favorable in the Uruguayan configuration (Chapter 4.1), but it imports one node the safeguards track must take note of: the eligibility of the biogenic CO_2 depends on the underlying biomass complying with the exclusively environmental criteria of Article 29, which re-enter the pathway at the ALUR plant and the forestry-residue streams (Chapter 5.1).[367] The certified supply chain therefore reaches, through the carbon source, into the forestry-cellulose complex whose social dimension civil society invokes against hydrogen (Chapter 4.4), yet certifies nothing social about it. The safeguards track responds in SM-2 and SM-4 by extending engagement and transparency duties to the project's carbon and feedstock interface, precisely because the compliance track cannot.

Traceability, finally, runs through the mass-balance chain of custody and the Union Database (Chapters 3.5.2 and 3.5.4). The output of Track 1 is the Proof of Sustainability: the instrument that constitutes market access and on which nothing in Track 2 may intrude (R1).

6.2.2. Track 2: The Social Safeguards Module as a complementary layer

The Social Safeguards Module (SSM) is conceived as a documented set of social criteria, indicators, evidence requirements and audit protocols against which a hydrogen or derivatives

[366] Delegated Regulation (EU) 2023/1184, Art. 4(1) and (2); generation of 14,474 GWh delivered to the SIN in 2024 according to MIEM (2026).
[367] Delegated Regulation (EU) 2023/1185, Annex, point 10(c).

project in Uruguay can be verified by an accredited third party, resulting in a conformity statement, referred to here as SSM verification, that the producer can present to offtakers, financiers, authorities and the public alongside, but strictly separate from, its Proof of Sustainability.

Three institutional docking options exist for such a module, and the choice among them need not be exclusive. The first is producer-level docking: the module is audited as a voluntary add-on within the same audit cycle as the recognized-scheme certification, by the same certification body, in the manner in which comprehensive schemes already attach voluntary sustainability requirements beyond the mandated core (Chapter 3.4). This is the fastest route and the one with the lowest institutional overhead, but it leaves the module without a governance home of its own. The second is national docking: the module is administered as an Uruguayan instrument, namely a safeguards protocol maintained under the Programa H2U architecture described in Chapter 4.2, with the state defining and updating the criteria and accredited private bodies performing verification. This mirrors, at national scale, the division of labor of the EU architecture itself, in which public rule-setting is combined with private conformity assessment (Chapter 3.5.3). The third is regional docking: the module becomes Uruguay's national specification of CertHiLAC's six LAC-specific attributes, submitted into the System Representative process whose attribute-definition task is still pending.[368] This is the option with the greatest systemic value, because it is the only one that closes the operative gap at the level at which it was identified; it depends, however, on a consolidation timetable Uruguay does not control (Chapter 3.6.5).

The proposal made here is to sequence the three rather than choose among them: begin with producer-level docking on the projects that will certify under a recognized scheme in any event, consolidate the criteria as a national protocol in parallel, and offer the result into the regional process once it exists in validated form. Section 6.4.2 develops this sequencing. The design that makes it possible is R6: because the module is specified independently of any host scheme, as a self-contained criteria catalogue with its own evidence and audit logic, it can be carried by an ISCC EU add-on audit today and by a CertHiLAC certificate tomorrow without redesign.

One boundary of the module must be drawn explicitly. The SSM is a project-level certification instrument, not a substitute for public policy. Criteria are confined to what is attributable to a given production project and verifiable at its level, consistent with the definition of social

[368] Cf. Hartmann et al. (2023), p. 37.

sustainability adopted in Chapter 3.4. Structural questions such as the distribution of fiscal revenues, national training policy or the recognition of indigenous descendants are affected by the module only at its edges, where a project-level duty (a qualification plan, a documented engagement process) can be defined. This boundary is not a limitation to be regretted but a condition of auditability: it is what separates a certifiable criterion from a political aspiration.

6.2.3. Interaction of the tracks across the project lifecycle

The two tracks are coordinated in time rather than in content. Uruguayan megaprojects pass through a defined institutional sequence, from Environmental Location Viability through Prior Environmental Authorization with environmental impact assessment under the high-complexity regime to construction, commissioning and operation (Chapter 4.2), and both certification tracks attach to this sequence at defined points. Table 5 sets out the alignment. Its logic implements R5: each SSM phase is timed so that the evidence it requires is largely generated by the regulatory step the project is undergoing anyway, and so that safeguards enter when influence over design is greatest: before the final investment decision, not after grievances have materialized. The construction phase receives its own verification window because Chapter 4.4 identified it as the phase in which the labor and influx risks concentrate and in which workforce numbers peak.

Table 5: Alignment of the two certification tracks with the Uruguayan project lifecycle (own design)

#	PROJECT PHASE Uruguayan instruments, Ch. 4.2	TRACK 1 RFNBO compliance	TRACK 2 Social Safeguards Module
1	**Pre-feasibility / siting** VAL	Certification concept; electricity-sourcing design (PPA structure, additionality)	SSM self-assessment; social baseline drawing on EIA scoping; engagement plan drafted (SM4); siting-alternatives evidence (SM2)
2	**Authorization** AAP / EIA, public hearing	Pre-audit; supplier declarations along the chain incl. CO_2 source	Initial SSM verification: criteria of all four areas at design level; consultation evidence from the legal process reused
3	**Construction**	Certification of installations as commissioned	Construction-phase surveillance: labor, influx, grievance operation (SM3, SM4); at least one on-site audit at workforce peak
4	**Commissioning / first production**	Initial recognized-scheme audit; first Proof of Sustainability; Union Database entry	Operational SSM verification: water metering and reporting live (SM1); permanent grievance mechanism operating (SM4)
5	**Operation** annual cycle	Annual surveillance audits; PoS issuance per consignment	Annual SSM surveillance, aligned with the same audit cycle; public annual safeguards report

Read stage by stage, the alignment works as follows. In the pre-feasibility and siting stage, ending with the Environmental Location Viability (VAL), Track 1 is confined to the certification concept and the electricity-sourcing design, and Track 2 to preparatory steps, a self-assessment, a social baseline, the draft engagement plan (SM-4) and the siting-alternatives record (SM-2); no third-party verification takes place yet. The first verification falls in the authorization stage, when the AAP procedure, the environmental impact assessment and the public hearing generate the documentary record, which the initial SSM verification reuses rather than duplicates. Construction is the stage in which the tracks diverge most: Track 1 only certifies installations as commissioned, whereas Track 2 requires surveillance of labor, influx and grievance operation (SM-3, SM-4) with at least one on-site audit at workforce peak. At commissioning both tracks become operative, with the first Proof of Sustainability and Union Database entry on Track 1 and live water metering (SM-1) and a permanent grievance mechanism (SM-4) on Track 2, and in operation both settle into one annual audit cycle. The criteria behind each stage are specified in Chapter 6.3, the introduction of the module itself in Chapter 6.4.2.

6.3. The Social Safeguards Module

6.3.1. Structure, Compliance logic and claim

The module is organized in the hierarchy that the gap analysis showed to be missing: each of the four safeguard areas, corresponding to the four clusters derived in Chapter 3.4 and confirmed as critical for Uruguay in Chapter 4.4, is specified as a set of criteria, each criterion carrying an indicator, an evidence base and a verification protocol (R3). Two compliance classes are distinguished, and the distinction is a deliberate design decision rather than an inherited convention. Critical criteria define the floor: they must be met for SSM verification to be granted or maintained, because they correspond to the risks Chapter 4.4 identified as capable of destroying local acceptance: unauthorized water use, unlawful land conversion, unsafe work, and the absence of any grievance channel. Progress criteria define the trajectory: they must be reported against, with documented improvement over successive cycles, because they correspond to the dimensions in which the value of the sector to its host context is built over time (local employment shares, gender inclusion, responsiveness of engagement) and in which a binary pass/fail test would either be trivially weak or arbitrarily strict. This two-class logic also resolves a tension inside CertHiLAC's own attribute set, which combines a floor-type formulation (exclusion of land conflict areas) with an ambition-type formulation

(positive social impact on neighboring communities) without distinguishing their verification logic.[369]

The claim produced by the module is deliberately modest in legal form and specific in content: a third-party-verified statement that the project conforms to the SSM criteria catalogue, version-dated, published, and renewable annually. It confers no market access and conditions none (R2). Its value operates through three channels: toward offtakers and financiers, for whom social performance is a component of bankability and verified project-level evidence reduces the cost of the due-diligence and reporting duties EU horizontal instruments impose on the largest importers (Chapters 3.4 and 3.5.5); toward the Uruguayan public, for whom it makes the conditions of production transparent and contestable; and toward the regional process, for which it constitutes a worked example of operationalization (R6). That the IFC financing of the Kahirós pilot already carries the Performance Standards into the sector (Chapter 4.3) indicates that the module would formalize a logic the market has begun to apply selectively, rather than introduce an alien one.

The four safeguard areas are now specified in turn. For each, the design rationale is stated first, identifying which Uruguayan risk form from Chapter 4.4 and which framework gap from Chapter 5 the area answers, followed by the criteria table (Tables 6-9). Threshold values marked as indicative (response times, reporting frequencies) follow the form that the international benchmarks prescribe without fixing numbers: IFC guidance requires prompt acknowledgement of a grievance together with a stated timeline for the response, and the UN Guiding Principles list a predictable procedure with an indicative time frame for each stage among the effectiveness criteria of non-judicial grievance mechanisms.[370] The 15-day and 60-day figures and the quarterly reporting interval are the author's proposals within these requirements and would be fixed in the validation process described in Section 6.4.2; they are stated numerically nonetheless, because an unquantified criterion would fail R3.

6.3.2. SM-1: Water stewardship and transparency

The water area responds to the finding of Chapter 4.4 that the social salience of water in Uruguay is decoupled from aggregate availability and turns on whether water use is transparent and verifiable. The criteria therefore target transparency and demonstrable restraint, not scarcity management, supplying the operationalization that CertHiLAC's two

[369] Cf. Hartmann et al. (2023), pp. 16 f. See Chapter 5.2.
[370] Cf. IFC (2009), section on receiving concerns and complaints; UN Guiding Principles on Business and Human Rights (2011), Principle 31(c).

water attributes lack[371] and filling the dimension's complete absence on the EU side (Chapter 5.2). The evidence base deliberately reuses what the Uruguayan process already generates: DINAGUA abstraction authorizations, the water chapters of the environmental files, and the basin assessment commissioned by MIEM (R5).[372] The criteria are set out in Table 6.

Table 6: SM1 criteria for water stewardship and transparency (own design)

SM1 · WATER STEWARDSHIP AND TRANSPARENCY	CLASS
W1 Authorized sourcing and full disclosure All water abstraction rests on valid authorizations; source, authorized and actual volumes (absolute and per unit of product) and discharge points are publicly disclosed.	CRITICAL
INDICATOR / EVIDENCE Valid DINAGUA authorization; metered abstraction ≤ authorized volume; disclosure document published	**VERIFICATION** Document review of permits and metering records; annual reconciliation
W2 Basin-compatible design The water-supply concept is consistent with the documented stress status of the affected basin; in basins under seasonal stress, no new direct abstraction from natural watercourses (storage- or reservoir-based solutions instead).	CRITICAL
INDICATOR / EVIDENCE Design documentation referencing the MIEM / Universidad de la República basin assessment; the Tambor reservoir solution illustrates a conforming design (Ch. 4.3 / 4.4)	**VERIFICATION** Review of the water-supply concept against the basin assessment at initial verification and upon design change
W3 Continuous monitoring, public reporting and drought protocol Consumption is metered continuously and reported publicly at defined intervals (indicative: quarterly); a drought contingency protocol subordinates industrial abstraction to human consumption, consistent with the constitutional status of water access established in Chapter 4.4.	CRITICAL
INDICATOR / EVIDENCE Metering coverage of all abstraction points; published reports; adopted contingency protocol	**VERIFICATION** Data audit; verification that reports were published on schedule; protocol review
W4 Efficiency trajectory and transboundary information Water intensity per unit of product is benchmarked and improvement documented; where the area of influence extends across the border, water information is shared through the applicable binational channel (CARU in the Río Uruguay constellation, Ch. 4.4).	PROGRESS
INDICATOR / EVIDENCE Year-on-year intensity reporting; record of transboundary communications	**VERIFICATION** Review of trend data and communication records in annual surveillance
CRITICAL Non-compliance blocks verification · PROGRESS Assessed on a documented improvement trajectory	

[371] Cf. Hartmann et al. (2023), p. 17.
[372] Cf. MIEM (2025a); see Chapter 4.4.

6.3.3. SM-2: Land and siting integrity

The land area responds to a risk profile in which formal tenure security coexists with procedurally contested conversion (Chapter 4.4). Its central design task is to operationalize the test that CertHiLAC names but does not define, the exclusion of land conflict areas, for a jurisdiction in which conflict manifests through procedure rather than unresolved tenure.[373] A second task is the treatment of indigenous-descendant communities in the absence of formal recognition and of any operative FPIC framework, the point at which Chapter 4.4 found international benchmarks losing their domestic anchor. Consistent with the conclusion that any credible safeguard must be defined at the level of the certification scheme itself, criterion L4 defines a scheme-level procedure. The procedure is deliberately framed as an engagement-and-documentation duty rather than a consent requirement carrying veto power, because a certification module cannot create rights that national law does not know. It can, however, require that a project identifies, engages and documents, and thereby closes the gap between benchmark and domestic legal order at project level. This is proposed explicitly as a bridging measure, without prejudice to the national recognition question, which is not the module's to resolve. The criteria are set out in Table 7.

Table 7: SM2 criteria for land and siting integrity (own design)

SM2 · LAND AND SITING INTEGRITY	CLASS
L1 Lawful siting and full footprint disclosure	CRITICAL
All land for plant, dedicated generation and transmission is held under a lawful, registered title (purchase, lease or easement, whether from private or public owners); any recategorization documents complete procedure under Law No. 18.308 including departmental involvement and publicity; the total direct and dedicated-generation footprint is disclosed in hectares.	
INDICATOR / EVIDENCE Complete siting dossier; recategorization file where applicable; published footprint statement	**VERIFICATION** Document review; cross-check against territorial planning records
L2 Conflict screening	CRITICAL
"Land conflict area" is operationalized as a defined screening: pending judicial or administrative challenges to the project's land basis are disclosed and risk-assessed; concluded proceedings are documented with outcome; no involuntary physical displacement occurs. Pending litigation does not automatically bar verification but triggers enhanced review.	
INDICATOR / EVIDENCE Sworn declaration by the operator; registry and court-record check; documentation of proceedings (e.g. the concluded challenge to the Tambor recategorization, Ch. 4.4)	**VERIFICATION** Independent record check by the auditor at initial verification and annually
L3 Siting alternatives and avoidance	CRITICAL

[373] Cf. Hartmann et al. (2023), pp. 16 f. See Chapter 5.2.

SM2 · LAND AND SITING INTEGRITY	CLASS
A documented alternatives analysis demonstrates preference for land already classified for industrial use and avoidance of native-forest clearance; zero unauthorized clearance is an absolute condition; authorized interventions are minimized and compensated as conditioned by the environmental authority.	
INDICATOR / EVIDENCE Alternatives analysis in the environmental file; clearance authorizations and compensation evidence; the Nuevo Paysandú relocation to pre-classified industrial land illustrates the avoidance logic (Ch. 4.4)	**VERIFICATION** Review of the environmental file; verification of the absence of sanctions for unauthorized clearance
L4 Indigenous-descendant engagement procedure The area of influence is screened for the presence or claims of indigenous-descendant communities (drawing on census ancestry data, salient in the northern departments, Ch. 4.4); where present, a culturally appropriate, documented engagement process is conducted, its outcomes recorded and responded to.	CRITICAL Screening and process PROGRESS Outcome documentation
INDICATOR / EVIDENCE Screening memorandum; engagement records; response documentation	**VERIFICATION** Review of screening and records; interviews with participants during the on-site audit

6.3.4. SM-3: Decent work and local benefit

The labor area draws its design directly from the redundancy finding of Chapter 5.2: in Uruguay, a criterion demanding “compliance with international labor standards” is discharged by lawful operation and adds nothing.[374] What is not redundant are the attributes Chapter 4.4 identified as decisive: the quality and safety of work in a high-hazard industry, the management of a front-loaded construction workforce in low-density settings, and the locality, durability and inclusiveness of the employment created. The area therefore certifies above the legal baseline where the baseline is silent (influx management, contractor cascades, qualification, gender) and certifies the operation of the baseline where its enforcement is the point, as in occupational safety under Decree No. 307/009.[375] The influx criterion E3 rests on the IDB’s sectoral risk characterization and Uruguay’s own pulp-mill precedent (Chapter 4.4).[376] The criteria are set out in Table 8.

Table 8: SM3 criteria for decent work and local benefit (own design)

SM3 · DECENT WORK AND LOCAL BENEFIT	CLASS
E1 Occupational safety management for a high-hazard industry A documented OSH management system implements Decree No. 307/009 across all phases, with a construction-phase plan reflecting the peak-workforce risk; incident and near-miss rates are tracked and reported.	CRITICAL

[374] See Chapter 5.2 with the sources cited there.
[375] Decree No. 307/009 of 3 July 2009; cf. AHK Uruguay/GIZ H2Uppp (2025), pp. 13 f.
[376] Cf. Signoria/Barlettani (2023); on the pulp-mill precedent see Chapter 4.4.

SM3 · DECENT WORK AND LOCAL BENEFIT	CLASS
INDICATOR / EVIDENCE OSH system documentation; MTSS filings; incident statistics	**VERIFICATION** System audit; site inspection during construction surveillance
E2 Labor floor across the contractor cascade All labor, including subcontracted labor, is formally registered; freedom of association and collective bargaining are respected; the operator carries documented responsibility for subcontractor compliance.	CRITICAL
INDICATOR / EVIDENCE Registration evidence across contractors; contractual cascade clauses; absence of substantiated violations	**VERIFICATION** Document sampling across the contractor chain; worker interviews during the on-site audit
E3 Workforce-influx management For the construction phase, a documented influx plan addresses accommodation, pressure on local health and other services, community safety and the prevention of gender-based violence, with monitoring during construction.	CRITICAL Existence and operation of the plan
INDICATOR / EVIDENCE Influx management plan; monitoring records; liaison records with departmental services	**VERIFICATION** Plan review; construction-phase site audit; community-side interviews (SM4 linkage)
E4 Local employment and qualification trajectory Local-hiring targets by phase and skill level are published (the operator-announced share of roughly 70 % local recruitment in the HIF case, Ch. 4.4, illustrates the form) and achievement is reported; a qualification plan, agreed with national or departmental training institutions, responds to the documented technician shortage.	PROGRESS
INDICATOR / EVIDENCE Published targets; periodic achievement reports disaggregated by phase, skill level and origin; qualification plan and implementation evidence	**VERIFICATION** Review of reports against payroll-derived data; verification of qualification-plan implementation
E5 Gender inclusion Participation of women in technical and permanent roles is measured and reported; workplace policies address the influx-related risks identified for women; a gender-sensitive channel exists within the grievance mechanism (SM4).	PROGRESS
INDICATOR / EVIDENCE Disaggregated employment reporting; policy documentation; grievance-channel design	**VERIFICATION** Data review; interviews; consistency check with SM4

6.3.5. SM-4: Community engagement, transparency and grievance

The procedural area carries the heaviest load in the module, because Chapter 4.4 located Uruguay's most visible divergence between formal compliance and social legitimacy here: participation concentrated in the authorization stage, non-binding, and documented by who was convened rather than whose views prevailed. The design consequence is threefold. First, the module extends engagement beyond the hearing into a lifecycle structure (P1), institutionalizing what the cooperation agreements between MIEM and the departmental governments have begun ad hoc. Second, it requires the one instrument no general legal requirement currently mandates and that IFC Performance Standard 1 defines as the lifecycle

vehicle for raising and resolving concerns: a permanent, accessible, retaliation-protected grievance mechanism (P2).[377] Third, it shifts the evidentiary focus from convening to responsiveness (P4): the criterion is not that consultation occurred but that its input is traceably answered, the precise deficit the record of Chapter 4.4 made visible. The transparency criterion P3 gives Uruguay's Escazú commitments a project-level expression,[378] and where the area of influence is transboundary, as in the constellation of the Botnia/UPM precedent recurring in the HIF case, the engagement plan must cover it. The criteria are set out in Table 9.

Table 9: SM4 criteria for engagement, transparency and grievance (own design)

SM4 · ENGAGEMENT, TRANSPARENCY AND GRIEVANCE	CLASS
P1 Lifecycle engagement plan A published plan defines engagement instances for each phase (pre-application information, a construction-phase liaison structure, a standing exchange forum in operation), building on and consolidating existing departmental committee structures; where the area of influence crosses the border, the plan covers the transboundary public through the applicable channel.	CRITICAL
INDICATOR / EVIDENCE Published plan; records of instances held; transboundary communications where applicable	**VERIFICATION** Review of plan and records; attendance sampling; interviews
P2 Operational grievance mechanism A permanent, no-cost, publicly known channel receives complaints from any community member; receipt is acknowledged within a defined period (indicative: 15 days) and a reasoned response given within a defined period (indicative: 60 days); protection against retaliation is explicit; aggregate statistics on cases and resolution are published annually.	CRITICAL
INDICATOR / EVIDENCE Mechanism documentation; case register; published statistics	**VERIFICATION** Register audit; test of channel accessibility; complainant-side interviews on a sample basis
P3 Project transparency The key project information generated under SM1 to SM3 (water sourcing and consumption, land footprint, employment reporting) is published in accessible form and kept current, consistent with the access-rights framework of the Escazú implementation plan (Ch. 4.4).	CRITICAL
INDICATOR / EVIDENCE Public information point (physical and digital); currency of published data	**VERIFICATION** Verification of publication and currency at each surveillance
P4 Responsiveness A consultation-response register documents the input received in each engagement instance and the project's reasoned response, including design changes where made; the register is public.	PROGRESS
INDICATOR / EVIDENCE Response register; documented design responses (the relocation episode, Ch. 4.4, illustrates the category)	**VERIFICATION** Register review; cross-check of sampled inputs against responses

[377] Cf. IFC (2012); Mpinga/Klenke (2025), p. 8; see Chapters 3.4 and 4.4.
[378] Law No. 19.773 of 17 July 2019; Resolution No. 1.224/024 (Ministerio de Ambiente); see Chapter 4.4.

6.3.6. Consolidated mapping and verification

Table 10 closes the design by mapping the module back onto the frameworks it operationalizes. It demonstrates that every LAC-specific social attribute of CertHiLAC is carried, in Uruguayan calibration, by at least one safeguard area, and that each area rests on the international benchmark from which the clusters were derived in Chapter 3.4.

Table 10: Mapping of the Social Safeguards Module onto CertHiLAC attributes, IFC benchmarks and the Uruguayan risk profile (own compilation)

SM	SAFEGUARD AREA	CERTHILAC ATTRIBUTE OPERATIONALIZED (Ch. 3.6.2)	IFC (3.4)	URUGUAYAN RISK FORM ADDRESSED (Ch. 4.4)
SM1	**Water**	Sources and sustainable use of water; wastewater treatment	**PS3**	Trust in water governance; basin-level stress; transboundary salience
SM2	**Land**	Socially and environmentally harmonious land, excl. conflict areas; neighboring communities and indigenous peoples (land aspect)	**PS5, PS7**	Contested conversion and fragmentation; unresolved recognition question
SM3	**Labor**	Compliance with international labor standards (recast above the redundant baseline)	**PS2**	Quality, locality, durability, inclusiveness; construction-phase influx
SM4	**Engagement**	Positive social impact on neighboring communities (procedural core); consultation floor	**PS1**	Effectiveness, bindingness and continuity of participation

The assurance architecture follows the conformity-assessment logic of the compliance track, extended by the competences the social content requires. Verification is performed by certification bodies accredited to ISO/IEC 17065 (Chapter 3.5.3), whose audit teams must include demonstrated social-auditing competence; the existing national quality infrastructure, including the technology laboratory LATU already engaged in the sector through the Sectoral Fund (Chapter 4.2), offers anchoring for building this capacity. The audit cycle mirrors Table 5: an initial verification at the authorization stage, an on-site surveillance at the construction workforce peak, an operational verification at commissioning, and annual surveillance thereafter, each combining document review, site inspection and stakeholder interviews sampled beyond the project's own nominees. Combining these audits with the recognized-scheme audits the producer undergoes in any event (same body, same visit, separate reports) is the single most effective cost-containment measure available and a direct application of R5's economy logic to assurance itself.

Non-conformity handling enforces the two-class logic. Failure of a critical criterion suspends SSM verification until remediated; failure to demonstrate progress on a progress criterion over two consecutive cycles downgrades the verification statement and is disclosed in it. In no case does an SSM finding touch the Proof of Sustainability: the sanction operates through the loss of the verified claim and through whatever contractual weight offtakers and financiers have attached to it, never through market access (R1, R2). This strict separation is not a weakness of the design but its condition of possibility: it is what keeps the module WTO-clean, voluntary in law, and therefore adoptable now, without awaiting any change in EU or regional rules.

6.4. Implementation in Uruguay

6.4.1. Institutional anchoring and governance

The module needs a custodian, a validation forum and an assurance infrastructure, and Uruguay possesses recognizable candidates for all three. The natural custodian is the Ministry of Industry, Energy and Mining acting through the Programa H2U, whose mandate under Presidential Resolution 294/022 already covers regulatory development, capacity building and communication, and whose inter-institutional group convenes the ministries whose portfolios the module touches (Chapter 4.2). One adjustment is necessary and should be named: the group as constituted does not include the labor ministry, whose competence SM-3 directly engages; a module governance body would need to add the Ministry of Labor and Social Security alongside the Ministry of Environment's existing seat. Beyond the state, the governance design should draw the consequence of a finding this thesis has now encountered twice: schemes with civil-society actors in their governance apply more stringent social criteria, while schemes with civil-society actors in their governance tend to apply more stringent social criteria, while competition among schemes can exert downward pressure on the stringency of social requirements (Chapters 3.4 and 3.5.5).[379] A standing advisory body comprising operators, trade unions, departmental governments, civil-society organizations and academia, the actor set whose engagement the record of Chapter 4.4 documents, is therefore proposed not as ornament but as the structural safeguard against the module itself degenerating into a checkbox.

The validation forum, understood as the forum in which the module itself, not individual projects applying under it, is validated before its first use, need not be created: the Strategic Environmental Assessment of the hydrogen value chain already provides a participatory structure reaching from the institutional level to territorial sessions in the very departments

[379] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), p. 151.

hosting the megaprojects (Chapters 4.2 and 4.4). Routing the draft module through it, presenting the criteria catalogue in the EAE's instances and documenting how the input received changes it, would give the module the legitimacy of the process it is designed to certify, applying criterion P4 to the module's own genesis. The friction documented in the first territorial sessions is an argument for, not against, this route: a safeguards instrument validated only in Montevideo would begin its life exemplifying the deficit it claims to address.

6.4.2. Phased implementation

The sequencing proposed here is indicative in its time horizons and firm in its order, because each phase produces the input of the next.

Phase 1: drafting and validation. A technical working group under the H2U inter-institutional group, extended by the labor ministry and supported through the advisory body, consolidates the criteria catalogue of Section 6.3 into a version 1.0. Its first substantive task is the evidence-mapping that R5 requires: for every indicator, identifying which existing filing (environmental file, DINAGUA authorization, MTSS record, territorial planning act) already produces the evidence, so that the module's marginal documentation burden is known, minimized and defensible before any producer is asked to carry it. The draft is validated through the EAE's participatory structure and published with a response register. The institutional context of this thesis is itself a candidate contributor: the third pillar of the Global Gateway Green Hydrogen action exists precisely to develop instruments of this kind (Chapter 1.2), and donor support through it and through H2Uppp could carry the development cost that should not fall on the first movers.

Phase 2: piloting on the project pipeline. The module is applied, as producer-level docking, to the projects that will pursue recognized-scheme certification in any event. The two megaprojects are the natural pilots: both stand before their final investment decisions, in the window in which safeguards can still shape design, and institutional docking points already exist on both, namely the high-level and technical follow-up committees established under the HIF memorandum of understanding and the community-engagement strategy prioritized in the H2Uppp partnership with ENERTRAG (Chapter 4.3). The pilots serve double duty: they test auditability in practice, that is, whether the evidence bases hold and whether the indicative thresholds are workable, and they generate the first SSM-verified statements, whose reception by offtakers and financiers is itself a finding.

Phase 3: consolidation and regional feed-in. The validated module is adopted as a national safeguards protocol under the custodian, with a defined revision cycle. In parallel, Uruguay

submits it into the CertHiLAC process as its national specification of the LAC-specific social attributes, the contribution the regional implementation plan is still waiting for, whose Step 3 expressly foresees validation pilots that the Phase 2 projects can supply.[380] This converts the calibration gap of Chapter 5.3 into the mechanism of the regional system's completion: not a regional average imposed downward, but a national operationalization offered upward. Should the regional consolidation stall, the scheme-agnostic design of R6 means the national protocol and the producer-level docking continue to function on their own. A further option available to the legislator, noted here as an option and not as part of the core design, is fiscal linkage: the investment-promotion matrix restructured by Decree No. 329/025 (Chapter 4.2) could score SSM verification among its indicators, creating an uptake incentive through domestic fiscal benefit rather than market-access conditionality. This channel is trade-law clean, but it is a first step from voluntariness toward inducement that would itself require public debate.

6.4.3. Risks and mitigation

Four risks are material, and the design already carries their mitigations; naming them tests whether it does so sufficiently. The first is the checkbox risk: a project could satisfy the documentary evidence of each criterion, obtain the SSM statement, and yet treat the module as a formality that changes nothing in how it engages with its surroundings. The verification protocols and the withholding of the statement guard against non-compliance, not against compliance without substance. The mitigations of the latter are therefore built into what is verified: the responsiveness criterion P4, which makes the answering of input the audited object; public reporting under P3, which exposes performance to the actors of Chapter 4.4; and civil-society presence in governance, the one variable the literature associates with sustained stringency (Chapter 3.4). The second is duplication and participation fatigue, the concern that the module adds instances to a landscape whose problem is the effectiveness, not the number, of instances. The mitigation is R5 operating as designed: the module certifies and consolidates existing processes wherever they exist, and adds only what no legal requirement mandates, above all the permanent grievance channel. The third is the non-uptake risk: a voluntary instrument no producer adopts certifies nothing. The mitigation is the demand-side logic of Section 6.3.1, offtaker and financier pull as evidenced in the sector's financing precedent and in the horizontal duties of the largest EU importers, reinforced, if the legislator so chooses, by the fiscal option of Section 6.4.2; the pilots of Phase 2, involving operators with existing certification track records and cooperation frameworks, are selected to

[380] Cf. Hartmann et al. (2023), p. 37 (Step 1) and pp. 36–54 (Step 3 pilots); see Chapter 3.6.5.

make first adoption probable rather than heroic. The fourth is institutional discontinuity, political rotation eroding a voluntary instrument. The mitigations are anchoring in the technically oriented, low-fluctuation positions that CertHiLAC's own governance design prescribes for its representatives,[381] a published protocol with a defined revision cycle rather than an informal practice, and the regional feed-in of Phase 3, which, once achieved, gives the module a second institutional home beyond the national political cycle.

7. Discussion

The introduction asked how Uruguay can design and operationalize a certification pathway that is EU RFNBO-eligible while integrating a verifiable social safeguards layer, and the analysis now permits explicit answers to that question and to its three sub-questions. To the first, certification is the condition under which renewable hydrogen becomes a marketable product for an export-oriented producer (Chapter 3.1), and the EU-RFNBO-compliant mechanisms define requirements of three kinds, electricity sourcing (renewable origin, additionality, temporal and geographical correlation), a 70 % life-cycle emission saving and mass-balance traceability into the Union Database, but no social requirement for RFNBOs, the social dimension being addressed by the EU through horizontal instruments outside the market-access rules (Chapter 3.5). To the second, CertHiLAC aligns with these requirements in its EU-market category and diverges in its LAC category, which names water, land, community and indigenous-related attributes the EU framework does not contain but names them without indicators, evidence bases or verification protocols, so that the comparison yields three gap types: substantive on the EU side, operational on the CertHiLAC side and a calibration gap common to both (Chapter 5). To the third, the pathway bridges these gaps through a two-track architecture in which RFNBO eligibility is evidenced through a Commission-recognized scheme, for which ISCC EU is the operative choice given the Paysandú operator's existing certification, and social performance is made verifiable through a Social Safeguards Module of four areas and seventeen criteria, calibrated to the risk profile of Chapter 4.4 and docked onto the same audit cycle without touching the market-access claim (Chapter 6).

The thesis did not test a hypothesis in the statistical sense, but it started from a working assumption: that market credibility and social legitimacy are best served by complementing the EU-aligned certification with a locally oriented layer rather than by a single instrument. The

[381] Cf. Hartmann et al. (2023), pp. 38 f.

analysis confirms this assumption for reasons that can now be specified rather than intuited. The EU route does not currently establish a social dimension for RFNBOs and, given the trade-law constraints examined in Chapter 3.5.5, its incorporation into the market-access criteria would face significant legal and institutional barriers; the schemes recognized by implementing decision mirror this scope, with RSB as the only scheme-level exception (Chapters 3.1 and 5.1); and legitimacy, unlike eligibility, is inherently context-dependent and cannot be assumed to follow from an instrument calibrated elsewhere, which is the generalized form of the calibration gap. The complement, conversely, should not be fused into the market-access claim, both for the legal reasons behind R2 and because fusion could shift the focus of a locally grounded social relationship toward the requirements and expectations of the EU market. Separation with coordination, two tracks sharing one lifecycle and one audit visit, is therefore not merely an administrative convenience but a direct answer to the design question. The results are clear at the level of architecture and nuanced at the level of content, where every criterion carries indicative values that await validation and where the module's central assumption, that verified transparency and institutionalized responsiveness build acceptance, is grounded in the literature but not yet in Uruguayan practice.

Set against the literature, the results confirm one observation, qualify another and add a step of their own. The literature on EU sustainability criteria had already observed that social criteria are less present than environmental ones in the recognized schemes and remain outside the binding requirements of the Directive; the present analysis confirms this for RFNBOs specifically and adds a qualification the earlier literature could not yet make: the expectation, documented before recognition, that the extension of ISCC EU to RFNBOs would carry social and water criteria into the hydrogen scope has not materialized for the three schemes recognized by implementing decision, while the RSB standard has moved in the opposite direction, so that the social dimension is not foreclosed by the EU framework but left to scheme-level choice, which makes a national module both possible and necessary.[382] The regional guidance underlying CertHiLAC framed water scarcity and coexistence with indigenous communities as the region's characteristic social challenges; the Uruguayan record confirms the relevance of these dimensions but locates the risk in perception and procedure rather than in scarcity or unresolved tenure, a finding that coincides with the emphasis of the social-license literature on trust-building and early, continuous engagement, with the justice framing of the hydrogen economy proposed by Dillman and Heinonen and with

[382] Cf. Mauger/Villavicencio-Calzadilla/Fleming (2024), p. 151; Cf. Tietze/Tsoumpa/Ullrich (2024), p. 24.

the recent AHK/GIZ study on social sustainability in Uruguay's hydrogen sector, which reaches a compatible diagnosis on participation.[383] What the thesis adds is the translation of that diagnosis into auditable criteria, a step the acceptance literature describes as necessary but generally does not perform.

The transferability of this contribution is asymmetric. The content of the module, the Uruguayan calibration of each criterion, cannot be assumed to be transferred wholesale: it is built from a constitutionalized water right, a specific litigation and relocation record, a specific labor-market geography and a specific participation history. The method may be more readily transferable, though this has not been tested here: derive the dimensions from international benchmarks, calibrate them against the national risk profile, operationalize them to auditability, dock the result onto the certification the producer needs anyway, and offer it upward into the regional system. For other CertHiLAC signatories, which may face the same operative gap and their own calibration gap, this method would be the module's exportable core, and a region in which several members feed nationally calibrated specifications into the shared attribute set could help reconcile, in a federated rather than uniform way, the tension between harmonization and calibration that Chapter 5.3 identified as inherent in any regional scheme.

Several results ran against the expectations with which the analysis began, and each can be traced to an assumption, a source or a change in the object of study. The most consequential is the RSB exception: the working assumption that the recognized route uniformly excludes social criteria held for the schemes formally recognized in December 2024 but not for the standard that completed the Commission's technical assessment in November 2025 (Chapter 3.5.3), and the design was adjusted to treat RSB as a scheme-level exception rather than to rest on a uniform claim. A second surprise concerned the grid routes of Delegated Regulation (EU) 2023/1184: the initial reading that eligibility under them would fluctuate with hydrology overstated their fragility, because the Regulation deems a share above 90 % or an intensity below 18 gCO_2eq/MJ to persist for five calendar years (Chapter 6.2.1), so that the argument for the dedicated-park default rests less on legal volatility than on the volume of electricity the megaprojects would draw from a system of roughly 14.5 TWh. Third, the object of study moved during the writing period: the first Sectoral Fund pilot was recorded as paused, the flagship project moved toward relocation under transboundary pressure and the EU's horizontal due-diligence directive was revised (Chapters 4.2, 4.4 and 3.5.5). None of these developments

[383] Cf. Hartmann et al. (2023), p. 8; Mpinga/Klenke (2025), p. 8; Dillman/Heinonen (2022); AHK Uruguay/GIZ H2Uppp (2025), p. 11.

alters the architecture, but each shows that the pathway is designed for a moving target, which is one reason its phased implementation begins with validation rather than with certification.

The reliability of the results varies by layer, and the limitations follow from it. The regulatory analysis of Chapters 3 and 5 rests on primary legal texts and scheme documents and is robust as of the date of writing; its principal uncertainty is temporal, since the recognition status of RSB, the Omnibus revisions and the CertHiLAC attribute definition are all in motion. The country analysis of Chapter 4 rests on permitting files, official statistics, peer-reviewed actor analysis and press reporting; its weakest elements are the project-status statements drawn from press sources, cross-checked against official inventories where possible but subject to revision, and the perception data, which come from one national opinion study and one local survey. The design of Chapter 6 rests on three critical assumptions: that producers will pursue recognized-scheme certification in any event, which the Paysandú precedent supports; that the evidence bases the Uruguayan process generates, from DINAGUA authorizations to environmental files, are complete enough to audit against; and that transparency and responsiveness are the levers of acceptance in the Uruguayan context, which is the module's untested core. Geographically the results are specific to Uruguay by design, and temporally they reflect the status of August 2026. The pathway is accordingly a conceptual model rather than an operational system: the indicative thresholds are proposals awaiting the validation process they themselves prescribe, no criterion has yet met an auditor, an operator or a community in practice, and the analysis is document-based without field research, so that stakeholder perceptions enter only through the surveys and records others have produced. Finally, the module's scope boundary of project-level attributability is a condition of auditability, but it means that the structural questions surrounding the sector, from the recognition of indigenous descendants to the distribution of the sector's fiscal value, lie beyond the scope of project-level certification and within the domain of public policy and political decision-making, where this thesis leaves them.

The implications differ by addressee. For project design, the central implication is timing: safeguards are least costly and most effective before the final investment decision, which is why the pathway ties the first verification to the authorization stage and the preparatory steps to siting (Chapter 6.2.3). For companies, the module converts diffuse social expectations into a defined evidence set that reuses what the Uruguayan permitting process already produces, and it offers verified project-level evidence that reduces the cost of the due-diligence and reporting duties which EU horizontal instruments impose on the largest importers (Chapter 6.3.1). For regulation and planning, the module can be introduced at national level without

new legislation, through the Programa H2U under MIEM and the audit infrastructure of the recognized schemes (Chapter 6.4.1), it provides an object for the validation pilots the CertHiLAC implementation plan foresees, and it shows one way of reconciling regional harmonization with national calibration. A further implication concerns timing between levels: CertHiLAC's attribute definition remains a pending step dependent on agreement among fourteen signatory states (Chapter 3.6.5), while Uruguay's two megaprojects are approaching their final investment decisions now (Chapter 4.3); if the social dimension of certification had to wait for regional consensus, it could arrive after the investment decisions it is intended to inform, which is why the module operates nationally and keeps the regional feed-in open (R6). For the social dimension itself, the implication is that verifiability and responsiveness, rather than additional consultation instances, are the variables most likely to change the acceptance dynamic documented in Chapter 4.4.

Four questions remain for future research. The first is empirical: whether verified transparency and institutionalized responsiveness in fact build acceptance in the Uruguayan communities concerned, for which the Phase 2 pilots would generate the first evidence and a before-and-after study of perception around a piloting project would be the natural design. The second is comparative: whether the method transfers to other CertHiLAC signatories with different risk profiles, which would test the federated model suggested above. The third is legal: how a scheme-level social layer of the RSB type and a national module of the SSM type could coexist or be mutually recognized, and whether the WTO analysis of Chapter 3.5.5 would change if social criteria were demanded by purchasers rather than by regulators. The fourth is regional: how CertHiLAC's attribute definition, once agreed, should absorb nationally calibrated specifications without losing comparability, a question this thesis could only pose in the form of a worked example.

8. Conclusion

This thesis set out to answer how Uruguay can design and operationalize a certification pathway that is EU RFNBO-eligible while integrating a verifiable social safeguards layer suitable for green hydrogen projects. Its main findings can be summarized in four points. First, certification is the condition under which renewable hydrogen becomes a marketable product for an export-oriented producer, and the operative requirements are those of the EU RFNBO framework, a cumulative regime that applies irrespective of where production takes place and is evidenced through Commission-recognized schemes. Second, this framework does not currently establish mandatory social safeguards as a certification criterion, and the schemes

recognized by implementing decision follow the same scope, with the RSB standard as the one scheme-level exception. Third, the regional system CertHiLAC names the social attributes the EU framework omits but has not yet given them indicators, evidence bases or verification protocols. Fourth, Uruguay's critical social risks are risks of perception and procedure rather than of scarcity or weak law: they concern the transparency of water use, the procedure of land conversion, the quality and locality of employment, and the responsiveness of participation.

On this basis the three sub-questions can be answered explicitly. Certification has a central role in Uruguay's hydrogen strategy because access to the EU market runs through it, and the EU-RFNBO-compliant mechanisms define renewable electricity sourcing, a 70 % greenhouse gas saving and mass-balance traceability, but no social requirement (sub-question 1). CertHiLAC aligns with these requirements in its EU-market category and differs in its LAC category, whose social and water attributes have no counterpart on the EU side but remain unoperationalized, so that the comparison yields a substantive gap, an operative gap and a calibration gap (sub-question 2). A pathway that bridges these gaps is a two-track architecture: RFNBO eligibility is evidenced through a recognized scheme, a route a Latin American producer has already proven, while an auditable Social Safeguards Module of four areas and seventeen criteria, calibrated to Uruguay, makes verifiable what national law partly regulates but does not currently certify as a project-level social safeguard; the module docks onto the audits producers undergo anyway, is validated through the participatory structure Uruguay has already built, can be piloted on the projects now approaching their final investment decisions, and can be offered into the regional system as a worked example of operationalization (sub-question 3).

The contribution of the thesis lies less in the diagnosis, which the literature on social sustainability in certification had anticipated, than in its translation into an instrument: a criteria catalogue specified to the level at which an auditor can apply it, and an architecture that keeps social verification separate from market access for legal reasons while coordinating the two in one lifecycle. This matters for three reasons. For producers, it converts diffuse social expectations into a defined and reusable evidence set. For Uruguayan planning, it shows that a national safeguards layer can be introduced without new legislation and without waiting for regional consensus. For the regional process, it offers the calibrated national specification that CertHiLAC's implementation plan foresees but has not yet received.

The wider significance of the Uruguayan case derives from the conditions that make it a critical case. Where the electricity matrix is already nearly decarbonized, the technical threshold of eligibility is close to given, and the question that decides whether the sector's promised value materializes shifts to the social conditions of production: whether the communities that host the projects, but will not consume the hydrogen, can verify that the benefits claimed and the burdens imposed are as stated. The asymmetry between climate benefits that accrue globally and social costs that arise locally is not addressed by certification frameworks that measure greenhouse gas emissions alone; it can, however, be addressed, and this thesis has argued that a producer country need not wait for importing markets or regional systems to do so. Uruguay possesses the regulatory baseline, the institutional architecture, the pilot projects and, in the module proposed here, a workable design.

These conclusions are subject to the limitations set out in Chapter 7: the pathway is a conceptual model resting on document-based analysis, its thresholds are indicative, and its central assumption, that verified transparency and responsiveness build acceptance, remains to be tested. Future research should therefore validate and calibrate the indicators in the Phase 1 process, evaluate the pilots against the acceptance record of the host departments, observe the consolidation of CertHiLAC and the reception of a national specification within it, and examine whether the method transfers to other signatory countries. Over time, this would allow an answer to the question this thesis could only design for: whether making the social conditions of hydrogen production certifiable also contributes to improving them.

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9.3. Declaration of Authorship

I hereby declare that the present thesis was completed independently and without the use of any aids other than those indicated. Any ideas taken directly or indirectly from external sources have been clearly identified as such. To the best of my knowledge, this thesis has not previously been submitted in the same or a similar form to any other examining authority and has not yet been published.



Santiago, 01.09.2026

Annex (Literature Review)

N°	Key Words	Author(s)	Year	Title (Source)	Summary	Relevance in thesis	Gaps/Limitations	Reference
1	social sustainability, social criteria, energy justice	Zamagni et al.	2025	A Conceptual Framework for Assessing and Monitoring Social Risks and Impacts Related to Hydrogen Technologies and Their Value Chains (EU Publications Office)	Conceptual framework for assessing and monitoring social risks/impacts of hydrogen value chains (life-cycle view).	Methodological grounding for the social dimension (Ch. 3.4); social topics must be identified locally.	Not operationalized; not Uruguay-specific; screened, not cited.	Zamagni et al., EU Publications Office, 2025, DOI: 10.2760/8349525
2	certification, chain of custody, GHG accounting	Seebach/ Krieger (Öko-Institut)	2023	Certification for green hydrogen and Power-to-X: An introduction (International PtX Hub/ GIZ)	Introduction to certification needs, system elements, tracking approaches and relevant schemes for H_2/PtX.	Frames certification as a governance and market-access issue; core concepts for Ch. 3.1-3.2.	Introductory; status 2023.	International PtX Hub (2023)
3	European Union, certification, governance	Fleming (ed.)	2024	The Cambridge Handbook of Hydrogen and the Law (Cambridge University Press)	Edited legal handbook on hydrogen regulation across jurisdictions (definitions, certification, market design, ESG).	Regulatory framing for Ch. 3 and 5; the thesis draws on ch. 10 (see N°6).	Broad volume; context rather than primary source.	Fleming (2024)
4	certification, Latin America, social sustainability	Ángel/ Márquez	2022	Estándares de sostenibilidad para la regulación del mercado de hidrógeno: Estudio de certificación de hidrógeno (IDB-TN-2522)	Reviews global H_2 certification systems and core design elements (CertifHy, TÜV, GH2, EU efforts); LAC implications.	Conceptual framework for certification design; links certification to export readiness and market access (Ch. 3).	From 2022; later developments to be supplemented.	Ángel/Márquez (2022)
5	certification, European Union, chain of custody	Tietze/ Tsoumpa/ Ullrich (Fichtner)	2024	In-Depth Analysis of Green Hydrogen Certification Processes in the EU. Advisory Report as Guidance for the Development of Digital Solutions (Extended version; GIZ/H2Uppp)	H2Uppp advisory report on EU certification processes and schemes; guidance for digital solutions.	Process-level detail on EU certification for Ch. 3.	Status March 2024; pre-dates scheme recognitions.	Tietze/Tsoumpa/Ullrich (2024)

6	social criteria, certification, governance	Mauger/ Villavicencio-Calzadilla/ Fleming	2024	Sustainability Criteria for Renewable Hydrogen (ch. 10 in: Fleming (ed.) 2024)	Chapter on sustainability/social criteria in H_2 certification; governance composition shapes social stringency; 'race to the bottom' risk.	Key academic anchor for the social-safeguards gap (Ch. 3.4).	Conceptual/EU-focused.	Mauger/Villavicencio-Calzadilla/Fleming (2024)
7	CertHiLAC, Latin America, certification	Hartmann et al.	2023	Guide for the Implementation of a Hydrogen Certification System in Latin America and the Caribbean (IDB-TN-2861)	Proposes the voluntary regional scheme CertHiLAC: base/LAC-/EU-specific attributes, two categories, multi-stakeholder governance, action plan.	Central primary source: CertHiLAC description (Ch. 3.6), gap analysis vs. EU RFNBO (Ch. 5), social attributes.	Proposal, not evaluation; status updated by OLADE (2025) (N°20).	Hartmann et al. (2023)
8	RFNBO, Uruguay, GHG accounting	Hinicio	2024	Análisis del cumplimiento de productos obtenidos a partir de hidrógeno renovable y diferentes fuentes de CO_2 en Uruguay y Chile con la Directiva de Energía Renovable de la UE y los criterios RFNBO. Reporte Final (PCLMEA24032)	Applies EU RFNBO rules (additionality, correlation, GHG) to Uruguayan/Chilean projects and CO_2 sources.	Supports case study and feasibility framing (Ch. 4-5), incl. the distinct CO_2 sources of the two megaprojects.	RFNBO/GHG focus, no social criteria; grey literature.	Hinicio (2024)
9	voluntary standard, social sustainability, GHG accounting	Green Hydrogen Organisation (GH2)	2023	The Global Standard for Green Hydrogen and Green Hydrogen Derivatives 2.0 (GH2)	Voluntary global standard: strict GHG threshold plus ESG criteria across the project life cycle.	Comparison scheme (Ch. 3.1, 3.3); benchmark for mandatory social requirements (Ch. 5-6).	Not an EU-recognised RFNBO scheme.	Green Hydrogen Organisation (2023)
10	land rights, community engagement, voluntary standard	GH2	2022	Green Hydrogen Contracting Guidance: Land Acquisition and Use (GH2)	Guidance on land acquisition and use, community rights, responsible contracting.	Informs the land cluster (Ch. 3.4) and land safeguards (Ch. 6).	Voluntary; screened, not cited.	GH2 (2022), gh2.org

11	social sustainability, community engagement, voluntary standard	GH2	2023	Green Hydrogen Contracting Guidance: Achieving Sustainable Development with Green Hydrogen (GH2)	Guidance on embedding sustainable-development and shared-value outcomes for host communities.	Feeds the 'shared socioeconomic value' argument (Ch. 3.4) and benefit sharing (Ch. 6).	Voluntary; high-level; screened, not cited.	GH2 (2023), gh2.org
12	community engagement, grievance mechanism, voluntary standard	GH2	2023	Green Hydrogen Contracting Guidance: Community Consultation and Transparency (GH2)	Guidance on community consultation, transparency and engagement processes.	Supports the engagement/transparency/grievance cluster (Ch. 3.4) and procedural safeguards (Ch. 6).	Voluntary; screened, not cited.	GH2 (2023), gh2.org
13	social license to operate, community engagement, water	Mpinga/ Klenke	2025	Matter of Trust: Securing a Social License to Operate for Clean Hydrogen Projects (H2Global Foundation)	Defines 20 SLO dimensions in clusters (incl. land, water, health & safety, local value); recommendations and good practices.	Primary SLO source (Ch. 3.4); practice content for the SSM (Ch. 6).	Not a certification standard; grey literature.	Mpinga/Klenke (2025)
14	social license to operate, market access, social sustainability	World Bank (ESMAP/ H4D)	2025	Key Insights from Social Licensing to Operate (SLO) in Renewable Energy Projects: Applying Lessons to Clean Hydrogen Development (World Bank)	Lessons from hydropower/wind SLO for clean hydrogen: SLO shapes bankability and investment readiness.	Bankability-vs-acceptance argument (Ch. 3.4); framing for Ch. 6.	Transferred lessons, not H_2-specific empirics.	World Bank (2025b)
15	Uruguay, guarantee of origin, governance	International PtX Hub	2024	Análisis de las necesidades regulatorias para el desarrollo de proyectos de producción de hidrógeno verde y derivados en Uruguay (International PtX Hub/ GIZ)	Analyses regulatory needs for green H_2/derivatives projects in Uruguay (i.a. guarantees of origin, production).	Uruguay-specific regulatory map for Ch. 4.	Snapshot Feb 2024; Spanish; no named author.	International PtX Hub (2024)

16	social sustainability, labor standards, land rights	IFC	2012	Performance Standards on Environmental and Social Sustainability (IFC)	Eight Performance Standards for environmental and social risk management (i.a. PS1 assessment, PS2 labor, PS5 land, PS7 indigenous peoples).	Basis of the four social clusters (Ch. 3.4); benchmark for Ch. 5-6.	Project-finance framework, not H_2-specific.	IFC (2012)
17	energy justice, social sustainability, derivatives	Dillman/ Heinonen	2022	A 'just' Hydrogen Economy: A Normative Energy Justice Assessment of the Hydrogen Economy (Renewable and Sustainable Energy Reviews 167)	Energy-justice assessment (distributional, procedural, cosmopolitan, recognition) across the H_2 value chain.	Peer-reviewed anchor for the justice framing (Ch. 3.4).	Normative mapping, no case work.	Dillman/Heinonen (2022)
18	market access, GHG accounting, certification	IEA	2025	Global Hydrogen Review 2025 (IEA)	Annual global review: production, demand, costs, projects, policy, certification.	Market context for Ch. 1 and 3.1.	Global statistics; check page references.	IEA (2025a)
19	Uruguay, market access, governance	MIEM	2023	Green Hydrogen Roadmap in Uruguay (Hoja de ruta de hidrógeno verde, English version; MIEM)	National green hydrogen roadmap: domestic use and export ambitions.	Foundational Uruguay source (Ch. 1, 4).	Strategy document, not regulation.	MIEM (2023)
20	CertHiLAC, Latin America, governance	OLADE	2025	Nota técnica H2 (English version; OLADE)	Technical note (Aug 2025): CertHiLAC governance scheme defined; complementary regional initiatives.	Current implementation status of CertHiLAC (Ch. 3.6.5).	Short note.	OLADE (2025)
21	certification, guarantee of origin, European Union	CertifHy	n.d.	CertifHy – Guarantee of Origin and RFNBO Certification Scheme (scheme website)	Europe's first operational H_2 certification scheme: GoO plus RFNBO compliance scheme.	EU benchmark scheme (Ch. 3.1, 3.5); recognized route (Impl. Dec. (EU) 2024/3180).	Scheme documentation (grey literature).	CertifHy (n.d.)

22	certification, European Union, chain of custody	ISCC System GmbH	2025	ISCC EU System Documents 202-1 (v4.2), 202-2, 202-6 (v1.4-1, Jan 2025), 205-1	EU-recognised scheme for biofuels/RFNBOs/RCFs with mass-balance chain of custody; thesis uses the four System Documents listed.	Recognized route (Impl. Dec. (EU) 2024/3176); route used by HIF Global (2025/2026); comparator for CoC and CO_2 rules (Ch. 3, 5).	Scheme documentation; check current versions.	ISCC EU 202-1/ 202-2/ 202-6/ 205-1
23	energy justice, market access, social sustainability	Dejonghe/ Van de Graaf	2025	Green Colonialism or Green Transformation? The Equity Implications of Clean Hydrogen Trade (Political Geography 120)	Examines whether H_2 trade drives 'green transformation' or 'green colonialism' (domination, accumulation, appropriation vs. voice, stake, autonomy).	Academic support for the normative concern (Ch. 3.4, 6).	Conceptual; screened, not cited.	Political Geography 120 (2025), DOI: 10.1016/j.polgeo.2025.103338
24	certification, social criteria, voluntary standard	Goodwin et al.	2024	Sustainability Certification for Renewable Hydrogen: An International Survey of Energy Professionals (Energy Policy 192)	Survey (n = 179) on desirable sustainability features of H_2 certification; support for diverse (incl. social) criteria and harmonisation.	Support for Ch. 3.3-3.4; companion study to N°28.	Screened, not cited (the 2025 study is).	Energy Policy 192 (2024), PII: S0301421524002519
25	certification, market access, chain of custody	IRENA/ RMI	2023	Creating a Global Hydrogen Market: Certification to Enable Trade (IRENA/RMI)	Report on certification and harmonisation to enable cross-border H_2 trade.	Fragmentation/quality-infrastructure argument (Ch. 3.1-3.2).	Institutional report (grey literature).	IRENA/RMI (2023)
26	RFNBO, social criteria, voluntary standard	RSB	2025	RSB EU Standard for RFNBOs and RCFs (RSB-STD-11-103, v1.0)	RSB EU standard for RFNBO/RCF certification (11/2025); electrolysis producers must meet the full RSB Principles & Criteria incl. social principles.	Shows a recognized route CAN carry mandatory social criteria; qualifies and sharpens the SSM argument (Ch. 3, 5.1, 6.1, 7).	Certifying since 11/2025; no track record yet.	RSB (2025b)

27	social criteria, voluntary standard, governance	RSB	2023	RSB Principles & Criteria (RSB-STD-01-001, v4.0)	Twelve cross-cutting principles: water, soil, air, conservation, food security, land rights, human/labor rights, rural and social development.	Substantive social content behind the RSB route (Ch. 3.4, 3.5.5); reference for the SSM evidence logic (Ch. 6).	Not H_2-specific; applies via RSB-STD-11-103 (N°26).	RSB (2023)
28	certification, governance, social sustainability	Goodwin et al.	2025	Expert Views on the Legitimacy of Renewable Hydrogen Certification Schemes (Energy Research & Social Science 121)	Expert views on the legitimacy of renewable H_2 certification schemes and their governance.	Peer-reviewed anchor for the legitimacy/governance dimension (Ch. 3).	Expert-based; not LAC-specific.	Goodwin et al. (2025)
29	social license to operate, governance, community engagement	Gehman/ Lefsrud/ Fast	2017	Social License to Operate: Legitimacy by Another Name? (Canadian Public Administration 60(2))	Review of origins and meanings of the SLO concept and its relation to legitimacy theory.	Academic grounding of the SLO concept (Ch. 3.4).	Not H_2-specific.	Gehman et al. (2017)
30	social license to operate, community engagement, governance	Owen/ Kemp	2013	Social Licence and Mining: A Critical Perspective (Resources Policy 38)	Critique: industry-led SLO risks remaining risk management rather than genuine community accountability.	Critical counterweight in the SLO discussion (Ch. 3.4).	Mining focus; pre-dates the H_2 debate.	Owen/Kemp (2013)
31	social sustainability, Latin America, water	Signoria/ Barlettani	2023	Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean (IDB)	IDB guidance on EHSS risk management of green H_2 projects in LAC across the project cycle.	Bridges the IFC logic and the LAC hydrogen context (Ch. 3.4, 4.4).	Regional guidance (grey literature).	Signoria/Barlettani (2023)
32	Uruguay, governance, social sustainability	Waiter/ Cohanoff/ Contreras	2025	Green Hydrogen in Uruguay: An Analysis of Actors and Relationships from a Science, Technology, and Society Perspective (Trilogía CTS 17(36))	Peer-reviewed STS mapping of the actors and relationships shaping green H_2 development in Uruguay.	Uruguay-specific governance landscape (Ch. 4); institutional anchoring (Ch. 6.4).	Actor mapping, not certification analysis.	Waiter/Cohanoff/Contreras (2025)

33	Uruguay, social sustainability, labor standards	AHK Uruguay/ GIZ H2Uppp	2025	Sostenibilidad social en la producción de hidrógeno verde y sus derivados en Uruguay (AHK Uruguay/ GIZ H2Uppp)	Study on the social sustainability of green H_2/derivatives production in Uruguay (11/2025).	Most directly on-topic Uruguay social source (Ch. 4.4, 6).	Grey literature; link stability to be checked.	AHK Uruguay/GIZ H2Uppp (2025)
34	certification, RFNBO, European Union	International PtX Hub	2026	EU RFNBO Certification Compendium: Key Insights, Challenges and Solutions from Expert Workshops and Case Studies in Non-EU Countries (International PtX Hub)	Compendium (3/2026) of insights, challenges and solutions on EU RFNBO certification in non-EU producer countries.	Current practice view on third-country certification (Ch. 3.5, 6-7).	Workshop-based (grey literature).	International PtX Hub (2026)