SUSTAINABILITY CRITERIA APPLIED

Water Governance and Sustainability Requirements for Green Hydrogen in Chile

DECHEMA
Gesellschaft für Chemische Technik
und Biotechnologie e.V.

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The Future of Our Energy

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Authors Millaray Sierra Olea and Daniela Jurado Betancur
(DECHEMA Society for Chemical Engineering and Biotechnology e. V.)

With contributions from
Maximilian Much, Dr. Thomas Track and Dr. Dinh Du Tran
(DECHEMA Society for Chemical Engineering and Biotechnology e. V.)
Rosa Stubenberg (WWF Germany)

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PROJECT BACKGROUND

This publication was produced within the framework of the Kopernikus project P2X, funded by the German Federal Ministry of Research, Technology and Space (BMFTR). The project investigates the development and assessment of technologies for the production of energy carriers and energy-intensive chemical products based on renewable energy, with the aim of advancing key technologies for sector coupling and supporting their market readiness.

Key components of the project include the construction and operation of a demonstration plant for the production of synthetic e-kerosene, as well as site-specific techno-economic analyses and life cycle assessments. The resulting findings are used to evaluate the scalability of the technologies and their transferability to other regions. In addition, the project addresses issues related to the environmental and social sustainability and acceptance of Power-to-X (PtX) technologies at national and international levels, involving relevant stakeholders along the entire value chain, including project developers, industrial off-takers, policymakers and public authorities, representatives of civil society, research institutions, and financial institutions.

Overall, the project results outline pathways toward a sustainable PtX economy from ecological, economic, and societal perspectives.

This publication is part of a publication series.

All publications will be published during the course of the year 2026 and are available **here.**

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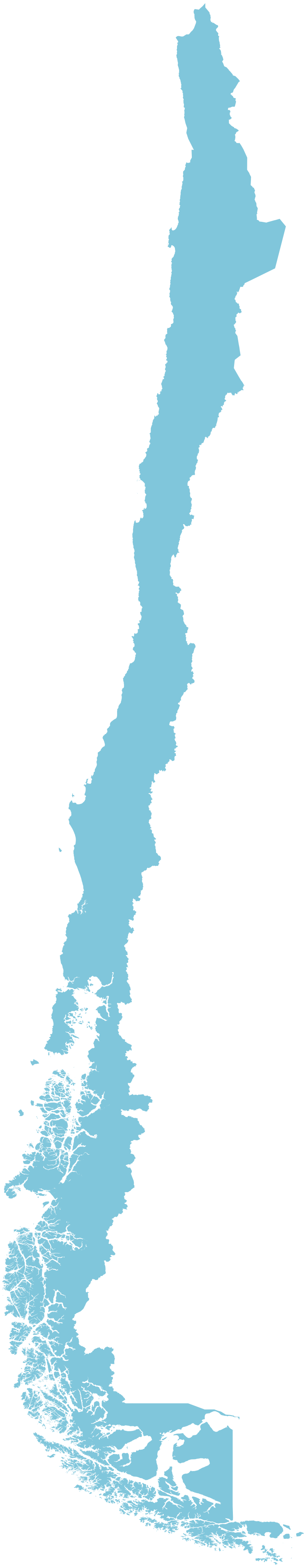
LIST OF ABBREVIATIONS

AEL	Alkaline Electrolysis
BNA	National Water Bank *(Banco Nacional del Agua)*
CBI	Climate Bond Initiative
CMS 70	Standard CMS 70, TÜV SÜD
CO_2	Carbon dioxide
CSDDD	Corporate Sustainability Due Diligence Directive
C_xH_y	Synthetic hydrocarbons
DAAs	Water Use Rights *(Derechos de Aprovechamiento de Aguas)*
DGA	General Water Directorate *(Dirección General de Aguas)*
DIRECTEMAR	General Directorate of the Maritime Territory and Merchant Marine *(Dirección General del Territorio Marítimo y de Marina Mercante)*
DOH	Hydraulic Works Directorate *(Dirección de Obras Hidráulicas)*
EIA	Environmental Impact Assessment
ED	Electrodialysis
EDI	Electrodeionization
ESG	Environmental, Social and Governance
ESMS	Environmental and Social Management System
EU	European Union
FPIC	Free, Prior and Informed Consent
GH2	Green Hydrogen Organisation
H_2	Hydrogen
IFC	International Finance Corporation
IPT	Territorial Planning Instruments *(Instrumentos de Planificación Territorial)*
MD	Membrane Distillation
MDN	Ministry of National Defense *(Ministerio de Defensa Nacional)*
MED	Multi-Effect Distillation
MeOH	Methanol
MMA	Ministry of the Environment *(Ministerio del Medio Ambiente)*
MOP	Ministry of Public Works *(Ministerio de Obras Públicas)*
MSF	Multi-Stage Flash
N_2	Nitrogen
NDICI-GE	Neighbourhood, Development and International Cooperation Instrument–Global Europe
NH_3	Ammonia
O_2	Oxygen
OPEX	Operating Expenditure
PEM	Proton Exchange Membrane
PtX	Power-to-X
RFNBOs	Renewable Fuels of Non-Biological Origin
RO	Reverse Osmosis
RSB	Roundtable on Sustainable Biomaterials
SDG 6	Sustainable Development Goal 6
SEA	Environmental Assessment Service *(Servicio de Evaluación Ambiental)*
SEC	Specific Energy Consumption
SEIA	Environmental Impact Assessment System *(Sistema de Evaluación de Impacto Ambiental)*
SMA	Superintendence of the Environment *(Superintendencia del Medio Ambiente)*
SSFFAA	Undersecretariat for the Armed Forces *(Subsecretaría para las Fuerzas Armadas)*
UPW	Ultrapure Water



EXECUTIVE SUMMARY

Chile has positioned green hydrogen as a strategic pillar of its future economic development, with ambitions to become a major exporter of hydrogen and its derivatives. As production scales up, water emerges as a critical sustainability dimension. Electrolysis requires significant water inputs, and large-scale hydrogen deployment may place additional pressure on already stressed water systems in certain regions of the country.

At the same time, international hydrogen markets are increasingly shaped by sustainability expectations embedded in European Union (EU) legal frameworks, other international policy frameworks, and certification schemes. While the EU is not the only importing region influencing sustainability standards, EU and international instruments currently represent some of the most operationalised and widely referenced frameworks for hydrogen trade and certification.

This report examines how Chile's current water governance and regulatory context align with recurring water-related sustainability expectations emerging from these international frameworks. To enable structured comparison, the analysis identifies six recurring water-related sustainability criteria that commonly appear across policy instruments, regulations, certification schemes, and research literature. These criteria serve as an analytical benchmark for assessing Chile's preparedness under evolving global sustainability standards.

The six criteria considered are:

#01 **Water source transparency and documentation:** clear identification and disclosure of water sources, volumes, and local water stress conditions.

#02 **Water-use efficiency and minimisation:** efficient water use throughout hydrogen production, including measures to reduce losses and monitor consumption.

#03 **Avoidance of competition with drinking water and essential local uses:** safeguarding water access for human consumption, agriculture, and local communities.

#04 **Governance, permitting, and stakeholder participation:** transparent approval processes, public consultation, and grievance mechanisms.

#05 **Environmentally responsible desalination and discharge:** responsible management of seawater abstraction, brine, and marine ecosystem impacts.

#06 **Long-term water sustainability and cumulative impacts:** consideration of coastal and river basin-level pressures, climate change, and long-term water availability.

The analysis indicates that Chile shows relatively stronger alignment in established governance structures, including environmental impact assessment procedures, public participation mechanisms, and the recent legal prioritisation of human consumption and environmental protection under the reformed Water Code reform. However, gaps persist in relation to long-term coastal and river basin-level sustainability, cumulative impact assessment, and desalination-related environmental management. These weaknesses are particularly relevant in regions where hydrogen production may scale rapidly or co-locate with other water-intensive activities. As production expands, scrutiny is likely to focus on how effectively Chile can assess cumulative coastal and river basin pressures, manage marine impacts from desalination, and demonstrate long-term water security under climate variability. Addressing these areas will be central to maintaining credibility under evolving certification, financing, importing markets and local civil society.

Chile nonetheless possesses a solid institutional foundation upon which improvements can be built, including an established permitting framework and extensive operational experience with large-scale desalination. Targeted strengthening of coastal and river basin-level monitoring, cumulative impact modelling, marine oversight, and hydrogen-specific water efficiency guidance would enhance alignment. These areas present concrete opportunities for international cooperation, where EU regulatory practice and technical expertise could support improved data systems, desalination governance, and long-term sustainability planning.

Table 1 summarises how Chile's current water governance and regulatory framework align with the six recurring sustainability criteria identified across EU and international hydrogen frameworks. It highlights areas where Chile institutional foundations are already in place and criteria that remain only partially addressed or still emerging.

Table 1:
Summary of alignment between international water-related sustainability criteria and current Chilean water governance.

WATER RELATED CRITERIA	ALIGNMENT WITH CHILE	KEY OBSERVATION
Water source transparency and documentation	Partially aligned	Disclosure required through EIAs and DAAs, but monitoring quality varies across regions
Water-use efficiency and minimisation	Uncertain / emerging	No hydrogen-specific efficiency benchmarks; relies on industry practice
Avoidance of competition with drinking water and essential local uses	Partially aligned	Water Code prioritises human consumption; no hydrogen-specific restriction on freshwater use
Governance, permitting, and stakeholder participation	Partially aligned	Established EIA and consultation procedures, but regional capacity varies
Long-term sustainability and cumulative impacts	Weak alignment	Project-based assessments; limited systematic evaluation of cumulative basin-level pressures
Environmentally responsible desalination and discharge	Weak alignment	Experience with individual plants, but cumulative marine impacts and brine regulation remain insufficiently addressed

1 INTRODUCTION AND SCOPE

The global expansion of green hydrogen and Power-to-X (PtX) value chains is increasingly shaped by sustainability considerations that extend beyond greenhouse gas mitigation. Among these, water availability and water governance emerge as critical dimensions, particularly in regions where large-scale hydrogen production may intersect with existing water stress. As countries position themselves within emerging hydrogen trade networks, questions of resource sustainability, regulatory coherence, and cross-border expectations become central.

Against this backdrop, Chile represents a particularly relevant case for examining how water-related sustainability expectations emerging from international hydrogen markets may interact with national regulatory and environmental conditions in a major prospective exporting country.

1.1 Chile as a Strategic Case Study for Sustainable PtX Trade

Chile has emerged as a strategically relevant partner for the EU in the development of international green hydrogen supply chains.

As PtX technologies approach industrial scale, questions of location, infrastructure compatibility, and resource availability become increasingly decisive. While the EU aims to expand domestic renewable hydrogen production, projected demand is expected to exceed internal supply capacity. The EU has therefore explicitly integrated hydrogen imports into its long-term defossilisation strategy, with Germany expected to rely substantially on international sources.

In this context, Chile has emerged as a strategically relevant partner for the EU in the development of international green hydrogen supply chains. The country combines exceptional renewable energy potential with an export-oriented hydrogen strategy and large-scale production ambitions for green hydrogen and ammonia. It also offers comparatively stable political and economic conditions and has engaged in bilateral and EU-level cooperation initiatives aimed at strengthening sustainable trade, and resilient supply chains (European Commission, 2025).

Within the framework of the Kopernikus project P2X, where the development and refinement of sustainability criteria for international PtX trade constitutes a key analytical component, Chile was selected as a case study. Its strategic positioning as a future export hub makes it particularly suitable for examining how sustainability requirements relevant to international hydrogen trade can be applied in producing countries under specific regulatory and environmental conditions.

Importantly, the sustainability of hydrogen imports cannot be assessed solely based on greenhouse gas performance. It also depends on broader environmental, social, and governance dimensions, including resource use. In regions characterised by water scarcity or structural water insecurity, large-scale hydrogen production may create or intensify local resource pressures. Ensuring that environmental impacts are not externalised to producer countries is therefore central to the credibility of international sustainability frameworks.

Beyond its relevance as a potential supplier, Chile exhibits pronounced regional disparities in water availability alongside an evolving regulatory framework for water management and desalination. These characteristics make Chile a particularly relevant case for analysing how water-related sustainability criteria can be operationalised in an export-oriented hydrogen economy and how international trade can be aligned with responsible local resource management.

1.2 Scope and Objective of the Report

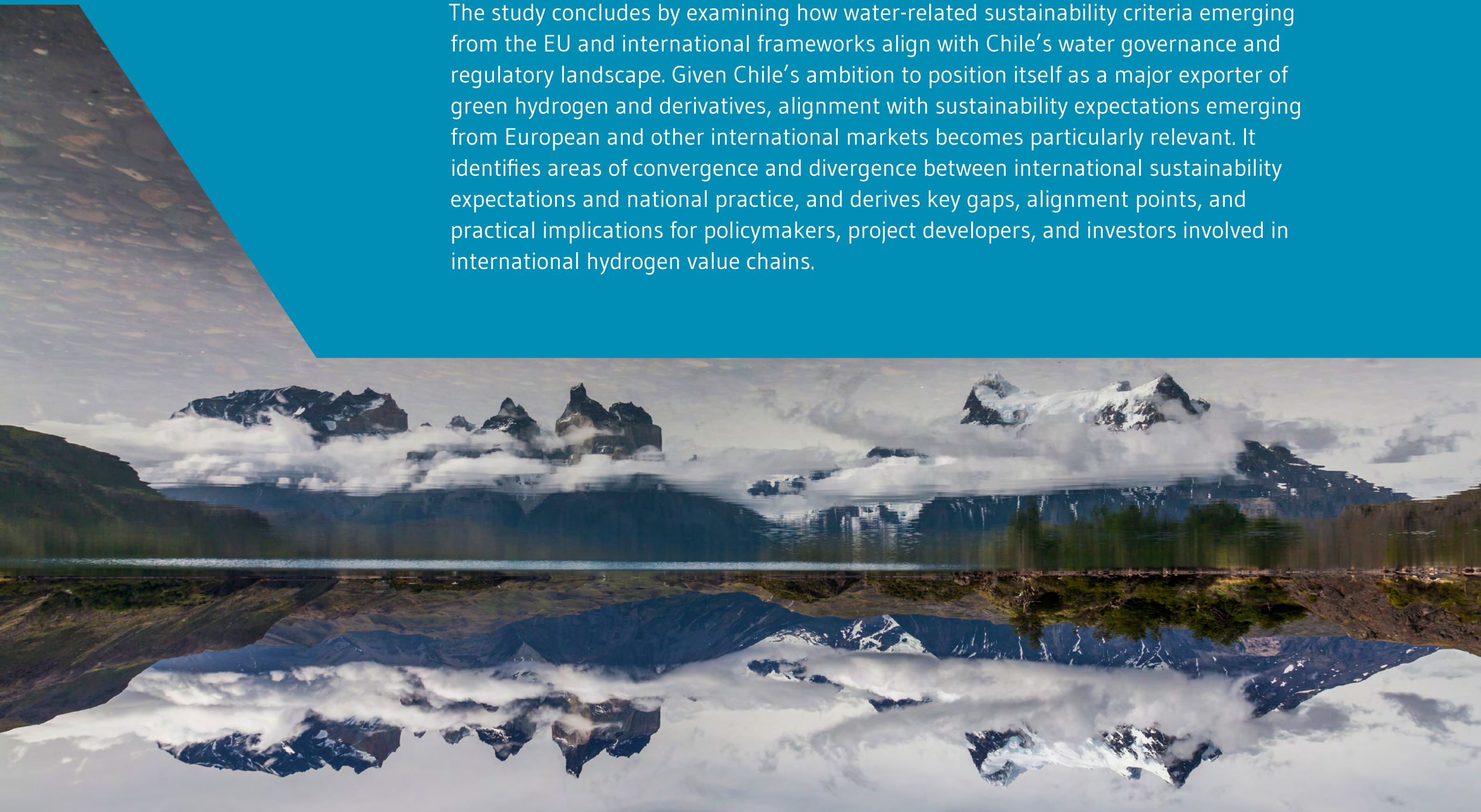
This report examines water as a central sustainability dimension of green hydrogen and PtX value chains. It provides a structured analysis of how water-related sustainability considerations are currently defined, governed, and implemented in emerging hydrogen frameworks, and how these considerations are reflected in national regulatory practice, using Chile as a case study.

This report examines water as a central sustainability dimension of green hydrogen and PtX value chains.

The first part of this report provides an assessment of the Chilean water context in relation to green hydrogen development. It reviews the institutional and regulatory framework governing water resources, assesses natural availability and competing uses, and examines the current and projected expansion of desalination infrastructure. In addition, it analyses projected water demand associated with announced green hydrogen projects.

In parallel, the report examines how water-related sustainability is addressed within EU and international green hydrogen governance frameworks, identifying recurring criteria that serve as a structured benchmark for comparison. It identifies key water-related criteria and reviews how they are reflected in policy instruments, regulatory frameworks, certification schemes, and relevant literature. In doing so, it establishes an analytical foundation for assessing coherence, identifying potential gaps, and enabling comparison across regulatory contexts.

The study concludes by examining how water-related sustainability criteria emerging from the EU and international frameworks align with Chile's water governance and regulatory landscape. Given Chile's ambition to position itself as a major exporter of green hydrogen and derivatives, alignment with sustainability expectations emerging from European and other international markets becomes particularly relevant. It identifies areas of convergence and divergence between international sustainability expectations and national practice, and derives key gaps, alignment points, and practical implications for policymakers, project developers, and investors involved in international hydrogen value chains.



2 PROJECT AND CONCEPTUAL BACKGROUND

To locate the analysis within its broader research and policy context, this section outlines the project framework and conceptual foundations relevant to sustainable PtX trade. It clarifies how water demand arises across PtX value chains and summarises key mitigation approaches discussed in the literature. Together, these elements provide the analytical basis for examining water-related sustainability challenges in export-oriented hydrogen production and for the subsequent assessment of Chile as a case study.

2.1 Kopernikus Project Framework and Conceptual Foundations of PtX

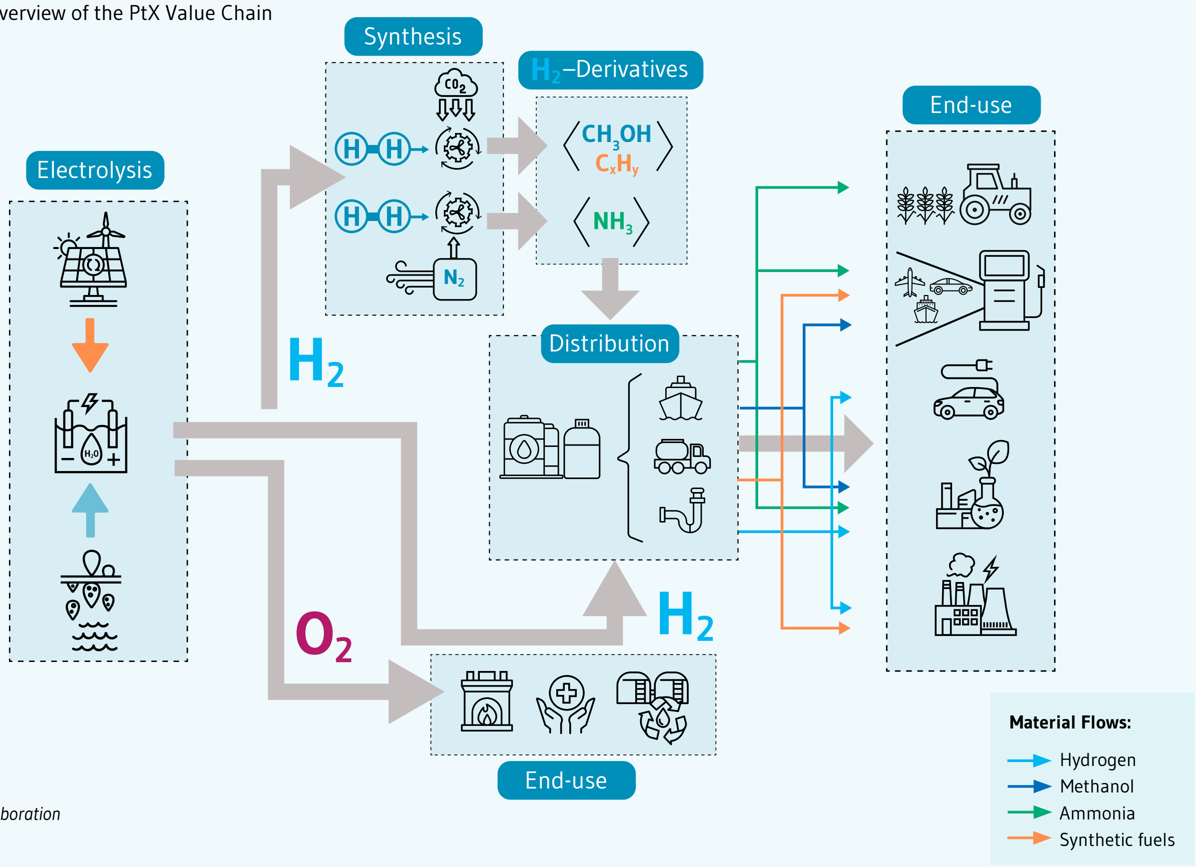
The transition toward climate neutrality requires not only the large-scale deployment of renewable electricity, but also the defossilisation of energy-intensive industrial processes and transport sectors that are difficult to electrify directly. In this context, green hydrogen and its derivatives, collectively grouped under the *Power-to-X (PtX)* concept, are expected to play a key role as versatile energy carriers and feedstocks across multiple sectors.

To address these challenges, the Kopernikus project P2X was established to develop and evaluate technologies that enable the production of renewable energy carriers, such as fuels and chemical products. Its objective is to implement viable pathways for replacing fossil energy sources and raw materials in the energy, transport, and chemical sectors, with solutions designed to be economically feasible, operationally flexible, scalable, and aligned with societal needs.

In its current third phase, the Kopernikus project P2X focuses on the demonstration initiative “*Power-to-Fuels*,” which aims to produce synthetic e-kerosene using green hydrogen and captured carbon dioxide. Beyond the technical implementation and operation of the plant, the demonstration is embedded within a broader analytical framework that considers ecological, economic, social, and regulatory dimensions. At the same time, PtX production pathways more broadly, including hydrogen and its derivatives such as ammonia, methanol, and synthetic fuels, are examined from a comparative location perspective in order to assess their scalability and transferability across different regional contexts. This approach enables the identification and further development of sustainability criteria that address not only carbon intensity and economic viability, but also resource management, site-specific environmental impacts, and socio-political conditions in potential production regions. It thereby establishes a structured basis for evaluating national and international PtX value chains in line with emerging requirements for responsible and sustainable hydrogen trade.

These PtX value chains are structured around a common principle: the conversion of renewable electricity into molecular energy carriers. An overview of this system is illustrated in **Figure 1**. Renewable electricity and water serve as the primary inputs for electrolysis, producing gaseous hydrogen (H_2) and oxygen (O_2). In water-stressed regions where freshwater availability is limited, desalinated seawater may be used as an alternative feedstock. Following electrolysis, hydrogen can either be stored and distributed for direct use or further processed through synthesis pathways. When combined with nitrogen (N_2) or carbon dioxide (CO_2), it enables the production of various chemical products, including ammonia (NH_3), methanol (CH_3OH), and other synthetic hydrocarbons (C_XH_Y). Oxygen, as a by-product, can be valorised through established markets in industrial, medical, and environmental applications.

Figure 1.
Schematic Overview of the PtX Value Chain



Source: Own elaboration

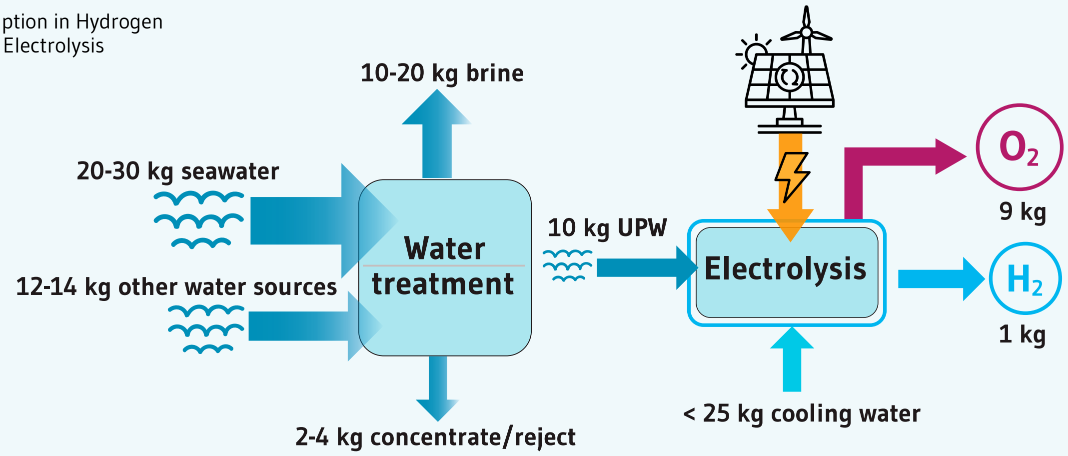
These hydrogen-based products enable a wide range of downstream applications. Ammonia may be used in fertiliser production, energy storage, or as a maritime fuel; methanol and synthetic hydrocarbons can serve as feedstocks for the chemical industry or as low-carbon fuels (e-fuels) in aviation and transport; and hydrogen itself can be applied in industrial processes, power generation, mobility, and the production of green steel. Together, these pathways illustrate the systemic relevance of the PtX concept, linking renewable electricity to multiple end-use sectors and supporting the substitution of fossil-based inputs across value chains.

2.2 Water Demand Across PtX Value Chains

While PtX technologies are primarily discussed in the context of greenhouse gas mitigation and the energy transition, their resource requirements must also be considered within a comprehensive sustainability assessment of the concept. In this regard, water management emerges as a particularly relevant dimension, given that it constitutes the fundamental input for hydrogen production via electrolysis.

The water demand for electrolysis depends on multiple factors and cannot be defined as a fixed value, as it is influenced by process parameters, the composition of the input water, and the climatic and hydrological conditions at the site. A baseline, however, is given by the electrolysis reaction itself. In this process, water is consumed as a raw material and split into hydrogen and oxygen. Based on the underlying electrochemical reaction, the theoretical requirement is approximately 9 kilograms of ultrapure water (UPW) per kilogram of hydrogen. In practice, however, system inefficiencies and operational losses lead to water consumption exceeding the theoretical minimum, with typical values of approximately 10 kilograms per kilogram of hydrogen produced (Ausfelder et al., 2023; Peecock et al., 2026; Saravia et al., 2023)

Figure 2.
Water Consumption in Hydrogen Production via Electrolysis



Source: Own elaboration based on Saravia et al., 2023

As shown in **Figure 2**, beyond the electrolysis reaction, the type of water source is a key parameter influencing total water withdrawal. Green hydrogen production requires high water quality, characterised by low conductivity and minimal organic carbon. As a result, feedwater must be treated prior to entering the electrolysis system. During this treatment, only a fraction of the incoming water is converted into UPW, while the remainder is discharged as concentrate, or as brine in the case of seawater. Accordingly, lower-quality source water leads to higher withdrawal volumes for the same hydrogen output. For example, when seawater is used, recovery rates via reverse osmosis (RO) typically range from 30 to 50%, whereas for other sources such as surface water or wastewater, they generally range between 60 and 80% (IRENA and Bluerisk, 2023; Saravia et al., 2023).

In addition to the water directly required for hydrogen production, a cooling system is needed to dissipate the heat generated during electrolysis. The associated cooling water demand depends on site-specific conditions, such as ambient temperature, as well as system characteristics, including electrolyser type and the chosen cooling approach. Consequently, total water consumption can vary significantly across locations and plant specifications. In some cases, cooling alone can account for additional water consumption ranging from negligible levels up to around 25 kilograms per kilogram of hydrogen, depending on electrolyser efficiency and the cooling strategy employed, such as open-loop, once-through, or air-based systems (IRENA and Bluerisk, 2023; Saravia et al., 2024) . As an illustrative example, a Proton Exchange Membrane (PEM) electrolyser operating at approximately 80% efficiency and using a commonly employed open-loop cooling system exhibits a total water consumption of around 18 kilograms per kilogram of hydrogen, of which approximately 45% is associated with cooling. A more detailed analysis is presented in section 2.3.2.

Water use in the production of hydrogen-based derivatives such as ammonia, methanol, or other synthetic fuels is primarily linked to the generation of green hydrogen via electrolysis. In the subsequent process stages, water is not consumed as a chemical reactant in the synthesis of these derivatives. Instead, it is required only for auxiliary purposes, particularly cooling and process conditioning. Consequently, the overall water demand of derivative production is primarily determined by upstream hydrogen generation and technical support systems, rather than by the chemical conversion processes themselves.

2.3 Mitigation Approaches: Ensuring Sustainable Water Use in PtX

Mitigation approaches should aim to balance the increasing water demand of PtX processes with the protection of local and regional water systems.

The expansion of PtX technologies may require significant volumes of water, thereby placing additional pressure on already stressed freshwater resources. To avoid adverse impacts on water availability and support the sustainable development of PtX value chains, comprehensive water management strategies and mitigation measures are essential. These approaches should aim to balance the increasing water demand of PtX processes with the protection of local and regional water systems. In this context, efforts should focus on both improving water-use efficiency and exploring alternative water sources.

2.3.1 Influence of Electrolyser Technology on Water Consumption

In terms of water-use efficiency, electrolyser technology plays a key role in determining overall consumption. Commercial systems such as Alkaline Electrolysis (AEL) and Proton Exchange Membrane (PEM) electrolysis differ in their operational requirements, including water quality. While PEM electrolysers require ultrapure, low-conductivity water, AEL systems are less sensitive to impurities. Consequently, stricter purity requirements demand more intensive treatment, leading to higher process-related losses and increased overall water consumption (Mika et al., 2024). By contrast, technologies with greater tolerance to impurities offer increased flexibility in water sourcing and treatment, which can support more water-efficient system configurations. In this context, ongoing research is focused on developing electrolysis systems with reduced sensitivity to water impurities, particularly in the case of PEM technologies.

Beyond water quality, electrolysis efficiency also affects overall water demand by influencing cooling requirements. More efficient systems produce less waste heat and the associated need for cooling water. For example, PEM electrolysis generally exhibits lower cooling demand than AEL, as a larger share of the input energy is converted into hydrogen rather than lost as heat (IRENA and Bluerisk, 2023). Consequently, improving electrolysis efficiency not only lowers energy consumption and costs but can also significantly reduce water use.

2.3.2 Cooling Strategies for Electrolysis

To ensure stable electrolyser operation, excess heat must be effectively removed. In commercial operations, electrolysis systems rely on water-based cooling methods. Various cooling options are available, each associated with different water requirements, not only in terms of volume but also in whether the water is consumed or returned to its source. Consequently, the choice of the cooling system can have a significant impact on overall water consumption (Saravia et al., 2024).

In once-through cooling systems, water is continuously withdrawn from a natural water body, passed through the system for heat removal, and then discharged back into the same source. This approach is associated with comparatively high water withdrawal rates, typically in the range of 930 to 2460 kilograms per kilogram of hydrogen produced. Nevertheless, actual cooling water consumption and evaporation losses remain minimal. A key consideration, however, is the increased thermal load placed on the receiving water body. Provided that adequate water resources are available at the production site, such systems may constitute a viable option with a relatively low net water footprint (Saravia et al., 2024).

In locations where natural water resources are limited, cooling water withdrawal can be significantly reduced by operating systems in a recirculating mode. In electrolysis applications, open-loop cooling configurations are commonly employed, whereby the same water is reused multiple times. These systems typically rely on evaporative cooling to dissipate heat to the atmosphere, often using cooling towers. As a result, water withdrawal is substantially lower than in once-through cooling systems, generally ranging from 17 to 40 kilograms per kilogram of hydrogen produced (for electrolysis efficiencies between 60% and 80%, respectively). To prevent fouling and scaling, chemical additives are required for cooling water conditioning. In addition, maintaining water quality necessitates periodic blowdown, in which a portion of the cooling water is discharged. Consequently, a significant fraction of the cooling water is lost through evaporation and blowdown, resulting in a total water consumption of approximately 8 to 25 kilograms per kilogram of hydrogen produced (IRENA and Bluerisk, 2023; Saravia et al., 2024).

In order to eliminate evaporation losses and minimise water consumption, air cooling can be implemented. This approach represents a closed-loop cooling system, in which the cooling water circulates in a sealed cycle and does not come into direct contact with the atmosphere. Heat is removed through heat exchangers, where ambient air flows over tubes containing the cooling water. As the water and air do not come into contact, evaporation losses are avoided. However, these systems typically involve higher capital and operational costs due to increased complexity and energy requirements (IRENA and Bluerisk, 2023; Saravia et al., 2024).

2.3.3 Alternative Water Sources

While improving water-use efficiency can significantly reduce demand, it may not be sufficient in regions facing water scarcity. In these cases, the use of alternative water sources becomes increasingly important. Potential options include seawater, brackish water and wastewater (urban or industrial). The use of these alternative sources should consider not only the reliability of availability, ease of abstraction or collection, and transport requirements, but also the level of treatment required.

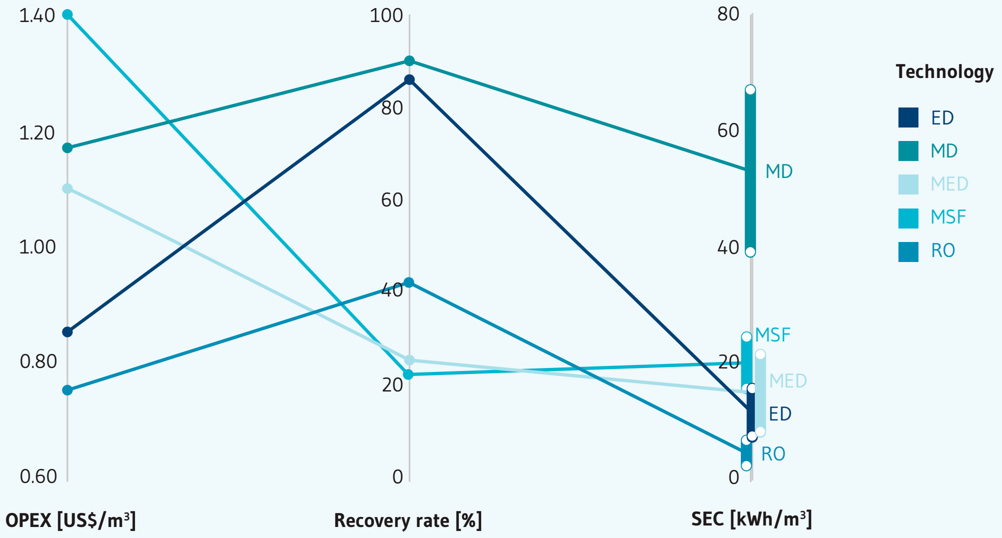
Among alternative water supply options, seawater is particularly relevant in water-scarce coastal regions. Desalination technologies are commonly classified into mechanical, thermal, and electrically driven processes, depending on the primary form of energy required. Mechanical processes predominantly refer to membrane-based technologies, where dissolved ions and other impurities are removed through selective membrane filtration. A notable example is reverse osmosis (RO), the most widely used technology for seawater desalination (Schmidt and Frank, 2023).

Thermal processes, in contrast, rely on heat to evaporate water, with ultrapure or deionised water obtained from the resulting condensate. The most established technologies in this category include multi-stage flash (MSF) and multi-effect distillation (MED) (Schmidt and Frank, 2023).

Electrically driven processes utilise an electric field to separate ions from the feedwater by transporting charged particles through cation and anion exchange membranes. In this context, electrodialysis (ED) represents a commercially available alternative (Schmidt and Frank, 2023).

Although the previously mentioned approaches are already commercially established, emerging water treatment methods such as membrane distillation (MD) may offer a more sustainable alternative. MD is a thermally driven process that exhibits high recovery rates across a wide range of water types, making it suitable for seawater as well as other alternative sources. Moreover, MD can be operated using low-grade heat from the electrolyser, thereby potentially reducing overall water demand associated with cooling requirements (Zhao et al., 2025).

Figure 3.
Comparison of Key Performance Parameters for Desalination Technologies.



Abbreviations:
ED = Electrodialysis
MD = Membrane Distillation
MED = Multi-Effect Distillation
MSF = Multi-Stage Flash
RO = Reverse Osmosis

Source: Own elaboration based on Schmidt and Frank, 2023

An overview of key parameters for the market-leading desalination technologies RO, MSF, MED, and ED is presented in **Figure 3**, with the emerging MD technology also included for comparison. The figure compares several relevant performance indicators, including recovery rate, defined as the percentage of freshwater obtained from the raw water source; specific energy consumption (SEC), representing the energy required to treat one cubic metre of raw water; and operating expenditure (OPEX), referring to the cost associated with treating one cubic metre of raw water (Schmidt and Frank, 2023).

The production of UPW suitable for electrolysis relies on a multi-stage treatment process, in which additional treatment steps are typically required. In the case of seawater, initial pre-treatment steps, such as fine screening, are used to remove suspended solids from the influent. To achieve the high purity required for electrolysis, the desalinated water can be further polished using processes such as electrodeionization (EDI) (Peecock et al., 2026; Simoes et al., 2021).

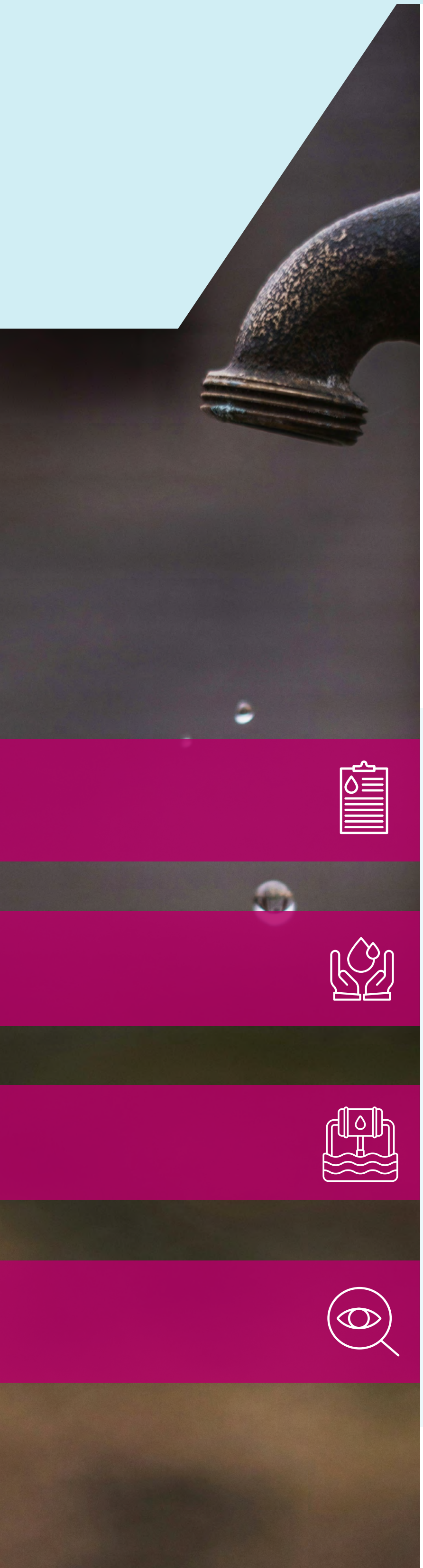
Although desalination increases overall energy demand, its contribution remains relatively small compared to the total energy requirements of hydrogen production (Hausmann et al., 2024). Nevertheless, environmental considerations, such as brine disposal and potential impacts on marine ecosystems, must be carefully addressed to ensure sustainable operation.

In addition to seawater, the use of wastewater offers a promising alternative, particularly in industrial or urban regions. Reusing municipal or industrial effluents can reduce pressure on freshwater resources and contribute to more circular water management practices. However, depending on the initial water quality, different treatment processes may be required to achieve the purity levels necessary for electrolysis.

As with seawater desalination, the previously described technologies can also be applied to wastewater treatment. Typical recovery rates for wastewater treatment reach up to approximately 90% for ED, around 65% for RO, and about 34% for thermal processes such as MSF and MED. In addition, further pre-treatment steps, such as fine screening and ultrafiltration, may be required to ensure adequate feedwater quality (Peecock et al., 2026; Schmidt and Frank, 2023; Simoes et al., 2021).

> The use of wastewater offers a promising alternative, particularly in industrial or urban regions. Reusing municipal or industrial effluents can reduce pressure on freshwater resources and contribute to more circular water management practices.

3 CHILE’S WATER AND DESALINATION CONTEXT FOR GREEN HYDROGEN



Chile has positioned green hydrogen as a strategic pillar of its long-term economic development, formalised through the adoption of the National Green Hydrogen Strategy in 2020 and reaffirmed through its 2026 update. Ambitious production targets are projected for both the northern and southern macro-zones, reflecting the country’s intention to become a major global producer of green hydrogen and its derivatives. The initial focus is on domestic market consolidation and industrial development, followed by a gradual expansion of export capacity.

The scale of these ambitions raises fundamental questions regarding water availability and sustainability, particularly in a country characterised by pronounced hydrological variability, increasing regional water stress, and recent legislative reforms in water governance, several of which remain subject to ongoing debate and implementation challenges.

This chapter provides a comprehensive assessment of Chile’s water context as it relates to green hydrogen development. Understanding this national framework is essential for evaluating how Chile may align with emerging international water-related sustainability expectations.

Section 3.1 examines how water resources are governed and regulated in Chile, including the administration of water abstraction, desalination, and effluent management, and clarifies the distribution of responsibilities among public authorities. It also outlines recent legislative reforms and pending regulatory developments shaping the country’s water governance framework.

Section 3.2 examines Chile’s natural water availability, competing sectoral demands, and basin-level water security constraints, with particular attention to regional imbalances. Given the strategic relevance of Magallanes as a prospective hydrogen hub, the status of water resources and existing structural vulnerabilities in this region are analysed in greater depth.

Section 3.3 positions desalination as a central component of Chile’s green hydrogen strategy. It assesses the current and projected expansion of desalination infrastructure, its territorial distribution, and sectoral orientation, and reviews announced green hydrogen projects nationwide. Particular attention is given to projected water demand and its implications for regional water systems.

Section 3.4 analyses Chile’s integration into emerging international hydrogen value chains, with a focus on cooperation with the European Union. It reviews the role of trade frameworks, financial mechanisms, and European project involvement in shaping the PtX sector, and considers how growing international engagement may influence Chile’s water governance and sustainability requirements.

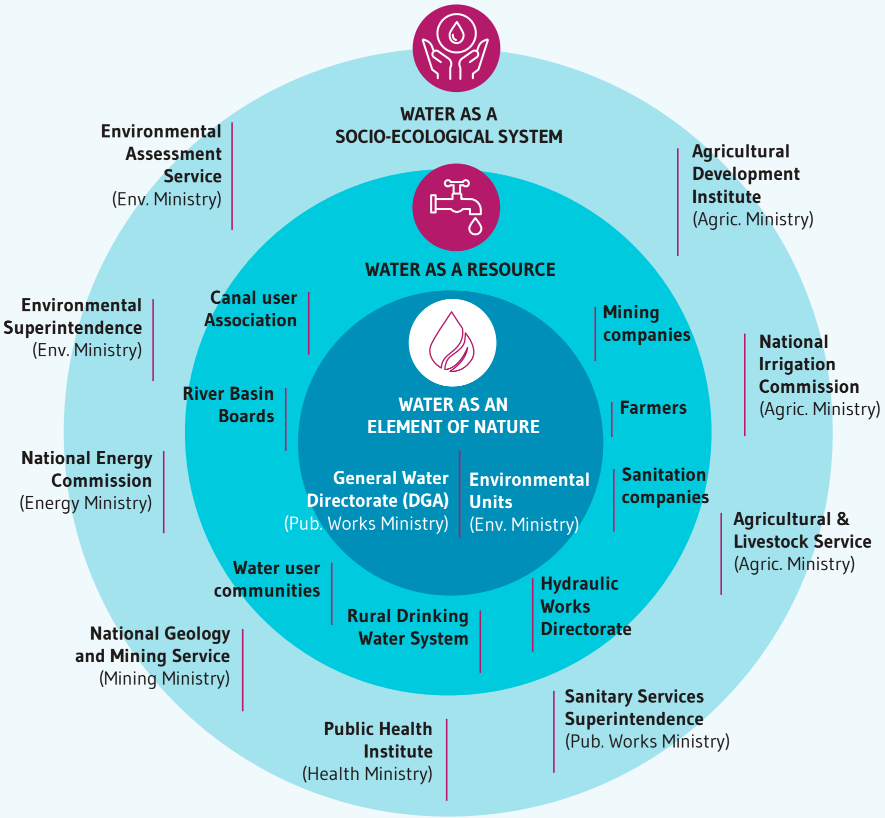
3.1 Water Governance and Regulation

3.1.1 Institutional Framework for Water Governance in Chile

Water governance in Chile is shaped by a broad set of policy instruments operating within an evolving water and climate policy framework. Instruments such as the reformed Water Code[1], the National Water Resources Strategy[2], the Climate Change Act[3], and the National Energy Policy[4] increasingly link water governance to climate, energy, environmental, and sustainable development objectives (Global Water Partnership, 2022). As a result, water is no longer governed solely within the water sector but through an interconnected policy framework spanning multiple domains.

Within this context, achieving a sustainable and resilient balance between water availability and water demand requires coordinated action to ensure sufficient and equitable access for all users while safeguarding aquatic ecosystems. This challenge highlights the need for integrated governance across multiple management domains, involving both public and private actors. The ways these actors are coordinated and aligned across sectors constitute what is understood as water governance in Chile (Álvarez Garretón et al., 2023). **Figure 4** provides a schematic overview of this approach, illustrating the three interrelated management domains and the key entities involved in each.

Figure 4.
Governance Structure of Water Management in Chile



Source: Adapted from Álvarez Garretón et al. (2023)

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[1] (Gobierno de Chile, 2022a)

[2] (Ministerio de Obras Públicas, 2020)

[3] (Gobierno de Chile, 2022b)

[4] inisterio de Energía, 2015)

The central domain shown in **Figure 4** corresponds to the management of water as an element of nature and is centred on the General Water Directorate (*Dirección General de Aguas, DGA*), the national water authority under the Ministry of Public Works (*Ministerio de Obras Publicas, MOP*). The DGA is the State authority responsible for ensuring balance and harmony in the use of terrestrial waters. Its functions include planning and monitoring water resources, protecting water quantity and quality, supervising water use and water user organizations, and enforcing compliance in surface waters and aquifers (Jaeger and Salgado, 2023)In carrying out these functions, the DGA is supported by the Ministry of the Environment (*Ministerio de Medio Ambiente, MMA*), which provides ecological and ecosystem information.

The second domain represents the management of water as a resource and encompasses activities related to extraction, distribution, use, and discharge. This domain brings together water users from the agricultural, mining, and sanitation sectors, as well as collective user organisations, such as: river basin boards and water user communities, that manage water distribution and operation in practice. These actors operate alongside public agencies, including the Hydraulic Works Directorate (*Dirección de Obras Hidráulicas, DOH*), which supports water management through the development and operation of hydraulic infrastructure (Álvarez Garretón et al., 2023).

The third domain represents the management of water as a socio-ecological system and is shaped by territorial and sectoral actors whose decisions indirectly influence water demand and use. It includes environmental authorities responsible for project evaluation and enforcement, such as the Environmental Assessment Service (*Servicio de Evaluación Ambiental, SEA*) and the Superintendence of the Environment (*Superintendencia del Medio Ambiente, SMA*), which regulate activities with potential impacts on water resources. In parallel, sectoral ministries and agencies–particularly those responsible for agriculture, energy, mining, and health–shape water demand by defining productive activities and sectoral policy frameworks (Álvarez Garretón et al., 2023).

3.1.2 Water Rights and Regulation of Continental Water Abstraction

Chile’s water governance has been fundamentally shaped by the Water Code enacted in 1981. Under this framework, water resources are legally defined as a national public good, while the State grants exclusive Water Use Rights (*Derechos de Aprovechamiento de Aguas*, DAAs) to individuals, companies, and organizations. Once allocated, these rights constitute private property, are independent of land ownership, and can be freely traded or leased on the water market (Araos and Roco, 2025).

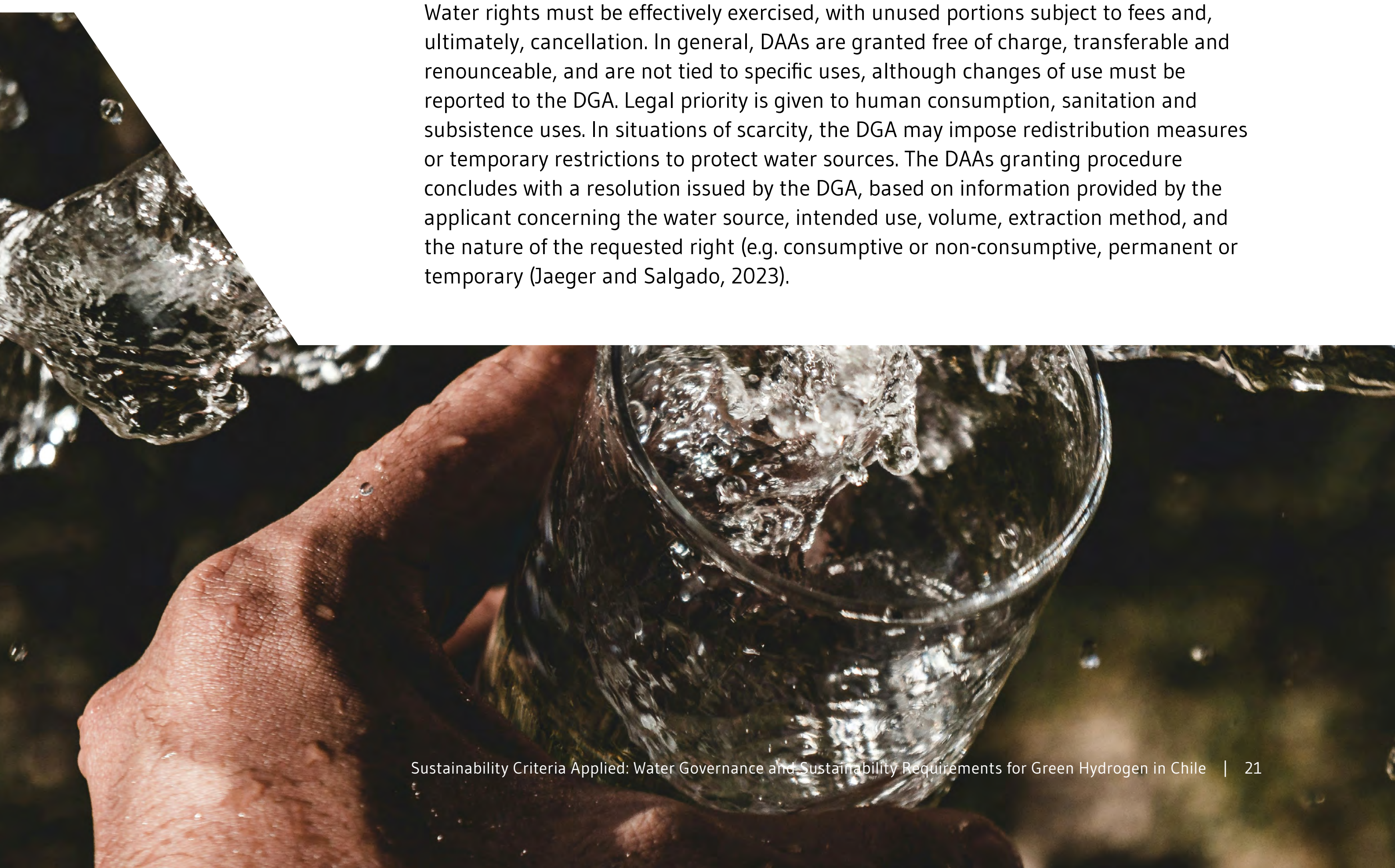
A defining feature of the original framework was the absence of any legally enforced priority of uses. This legislative neutrality allowed water rights to be allocated and exercised without distinction between different uses, including during periods of scarcity or drought (Celume Byrne, 2022; OECD, 2024). Combined with the state’s limited authority to regulate water use rights and weak market transparency, this approached contributed to the over-allocation and concentration of water rights, the overexploitation of aquifers, drinking water shortages, and recurrent conflicts among users.

The first significant reform of the Water Code in 2005 aimed to address some of the most visible shortcomings of the original framework. The reform introduced environmental safeguards and mechanisms to discourage the speculative accumulation of unused water rights. However, many underlying market failures persisted, and the reform did not substantially alter the existing concentration and monopolization of water rights (Larraín et al., 2010).

The 2022 Water Code reform established a legally binding priority for human consumption, sanitation, and subsistence use.

A more fundamental change occurred with the 2022 reform of the Water Code, which marked a decisive shift in Chile's water governance. The reform reaffirmed water as a national public good and formally recognized access to drinking water and sanitation as an essential human right. For the first time, it established a legally binding priority for human consumption, sanitation, and subsistence use in both the allocation and redistribution of water rights. In addition, the reform strengthened the public-interest role of water governance by introducing legal mechanisms to reserve water for subsistence and ecosystem preservation, prohibiting the granting of water rights over glaciers, reinforcing sustainability requirements for surface and groundwater, improving transparency in water rights and water use, and promoting basin-based territorial water management (Dirección General de Aguas, 2024). Within this legal framework, the DGA is the authority responsible for granting and administering DAAs for continental waters. DAAs constitute permits to extract water from natural sources for any purpose and regardless of the nature of the applicant, including human consumption, sanitation, or productive activities. Additionally, these rights are classified as either consumptive or non-consumptive. Consumptive rights allow the holder to extract and fully consume the water without the obligation to return it to the source, as is typically the case for drinking water supply, irrigation, or industrial processes. In contrast, non-consumptive rights require that the extracted water be returned to the watercourse after use, without significantly altering its quantity, quality, and overall system sustainability. Following the 2022 reform of the Water Code, newly granted DAAs take the form of renewable 30-year concessions, while pre-existing rights remain of indefinite duration but are subject to cancellation in case of non-use.

Water rights must be effectively exercised, with unused portions subject to fees and, ultimately, cancellation. In general, DAAs are granted free of charge, transferable and renounceable, and are not tied to specific uses, although changes of use must be reported to the DGA. Legal priority is given to human consumption, sanitation and subsistence uses. In situations of scarcity, the DGA may impose redistribution measures or temporary restrictions to protect water sources. The DAAs granting procedure concludes with a resolution issued by the DGA, based on information provided by the applicant concerning the water source, intended use, volume, extraction method, and the nature of the requested right (e.g. consumptive or non-consumptive, permanent or temporary (Jaeger and Salgado, 2023).



3.1.3 Regulatory Framework for Seawater Abstraction

Unlike continental waters, seawater in Chile is not governed by the Water Code and therefore falls outside the system of DAAs administered by the DGA. Like continental waters, however, seawater is classified as national public goods subject to State sovereignty. Access to seawater is regulated through the maritime concessions regime (Concesiones Maritimas), which requires prior State authorization for any infrastructure involving the use of seawaters, including desalination plants. Maritime concessions grant a temporary and revocable right to use public maritime assets and are administered and enforced by the Ministry of National Defense (*Ministerio de Defensa Nacional, MDN*) through the Undersecretariat for the Armed Forces (*Subsecretaría para las Fuerzas Armadas, SSFFAA*) and the General Directorate of the Maritime Territory and Merchant Marine (*Dirección General del Territorio Marítimo y de Marina Mercante, DIRECTEMAR*) (Jaeger and Salgado, 2023). Despite the existence of the maritime concessions system, Chilean law does not contain a specific regulatory framework governing the extraction of seawater as a water resource. The legal regime applicable to maritime concessions is primarily designed to regulate the use of physical maritime space rather than the abstraction of seawater itself, and does not establish substantive standards regarding extraction volumes, sustainability, or ecosystem impacts. This regulatory gap becomes evident when contrasted with the more detailed framework applicable to continental waters under the Water Code (Jaeger and Salgado, 2023).

Seawater in Chile is not governed by the Water Code and therefore falls outside the system of DAAs administered by the DGA.

In the absence of a dedicated legal framework for seawater abstraction, desalination projects are indirectly regulated through the Environmental Impact Assessment System (*Sistema de Evaluación de Impacto Ambiental*, SEIA), a preventive environmental management instrument that assesses compliance with applicable environmental standards. Although desalination plants are not explicitly listed as a standalone project category requiring mandatory entry into the SEIA, in practice such entry is typically triggered by associated works, including water conveyance infrastructure, potable water systems, industrial waste treatment and disposal, or coastal infrastructure works. Within the SEIA, projects are assessed either through an Environmental Impact Study or an Environmental Impact Declaration , depending on the magnitude of potential impacts, and the process concludes with an Environmental Qualification Resolution, the approval of which enables subsequent permitting (Gobierno de Chile, 2024a; Servicio de Evaluación Ambiental, 2023).

As a result, the regulatory framework applicable to desalination projects in Chile operates as a fragmented legal patchwork. Projects must navigate a combination of maritime concessions, environmental authorizations, and applicable territorial planning instruments (*Instrumentos de Planificación Territorial, IPT*), which together define the legal and land-use conditions for the installation and operation of desalination infrastructure. This fragmented framework is further shaped by sectoral permitting requirements that are currently undergoing significant reform through the new Framework Law on Sectoral Authorizations (Law No. 21.770). The reform aims to streamline approval processes without lowering regulatory standards and is expected to substantially reduce permitting timelines and improve investment conditions.

At the same time, recent reforms to the Water Code mandate the development of Strategic Water Resources Plans at the basin level. These plans adopt an integrated view of the hydrological cycle and explicitly consider desalination as a potential alternative water source. Although seawater remains formally outside the scope of the Water Code, these planning instruments may indirectly influence the location, justification, and integration of desalination infrastructure, highlighting the need for future coordination between desalination-specific legislation, water planning instruments, and territorial planning frameworks.

3.1.4 Legislative Developments in Seawater Desalination

Despite the steady increase in seawater desalination plants in Chile in recent years, the country still lacks a dedicated legal framework governing seawater extraction, desalination, and the subsequent treatment, distribution, and use of desalinated water for industrial or human use purposes. In particular, the legal status of seawater once desalinated remains unresolved, especially with regard to whether and how it should be integrated into the existing water governance system (Jaeger and Salgado, 2023).
In January 2018, a bill on the use of seawater for desalination (Bulletin No. 11.608-09) was introduced and is currently under second legislative review. The bill seeks to clarify whether maritime concessions authorize the consumptive use of seawater by explicitly recognizing this faculty and defining its scope, limitations, and the volumes that concession holders may extract and desalinate. It also reaffirms seawater as a national public good and assigns the DGA a role in safeguarding the public interest. This includes prioritizing the use of desalinated water for human consumption, sanitation, ecosystem protection, and sustainable productive activities, as well as allowing for the possibility of requiring concession holders to allocate a portion of desalinated water to human consumption (Jaeger and Salgado, 2023; Vicuña et al., 2022).

From an environmental perspective, the bill addresses an existing regulatory gap by explicitly requiring seawater abstraction and desalination projects to undergo environmental impact assessment under the SEIA, rather than being assessed only indirectly through related infrastructure. In addition, the bill mandates the subsequent adoption of a National Desalination Strategy. This strategy is intended to organize desalination activities at the national level by defining strategic geographic locations, establishing restricted zones, prioritizing water uses, promoting technologies and practices that minimize environmental impacts, and encouraging multipurpose desalination schemes that serve both productive activities and human consumption (Rámila et al., 2025; Vicuña et al., 2022).

3.1.5 Management and Regulation of Liquid Effluents

Within the framework of Chile’s Green Hydrogen Strategy, seawater desalination is expected to play a key role, increasing the relevance of environmental considerations related to liquid effluents, particularly brine discharges. Despite this growing importance, Chile lacks a specific legal framework regulating desalination plants and the management of brine. Instead, liquid effluent discharges are assessed through the SEIA and regulated under Supreme Decree No. 90/2000, which establishes emission limits for discharges to sea and fresh waters but does not address essential brine-specific aspects such as salinity thresholds or chemical composition.

As a result, Chile currently relies on international reference standards, primarily the Australian ANZECC Guidelines (1992), which is implemented through official SEIA technical guidelines for the assessment and implementation of brine discharges. This reliance highlights the absence of updated and locally adapted regulatory standards for brine management and points to the need for a more tailored regulatory approach to ensure environmentally sustainable desalination practices (Rámila et al., 2025).

All additional liquid waste streams, including operational and maintenance-related effluents, are subject to regulatory control depending on the selected discharge pathway. Discharges to public sewer systems comply with Supreme Decree No. 609/1998, discharges to sea and continental waters with Supreme Decree No. 90/2000, and discharges via infiltration to groundwater Supreme Decree No. 46/2003. In all cases, projects are required within the framework of the SEIA, to provide a projected characterization of the effluent and demonstrate compliance with applicable emission limits.

Beyond emission limits, projects must also comply with complementary water quality and sanitary regulations. These include Chilean Standard NCh 1333 on water quality requirements for different uses, Chilean Standard NCh 409 on potable water quality, and, where water is intended for human consumption, the sanitary authorizations and requirements established under the Sanitary Code (Green I&C, 2023; Servicio de Evaluación Ambiental, 2023).

3.1.6 Potential for Wastewater Reuse

Beyond continental water abstraction and seawater desalination, treated wastewater represents a potential alternative water source in Chile, particularly in the context of an emerging PtX value chain. Currently, approximately 22% of wastewater is discharged directly into the ocean through submarine emissaries after primary treatment. This corresponds to around 34 emissaries, which are primarily located in large urban areas.

This fraction of wastewater constitutes the only treated effluent that is not reused downstream, as wastewater discharged into surface water bodies is considered reintegrated into the water system managed by sanitation utilities responsible for providing wastewater treatment services. As a result, current discussions on wastewater reuse as a new water source focus primarily on effluent discharged through submarine emissaries, given its potential for productive uses, including agriculture and industry.

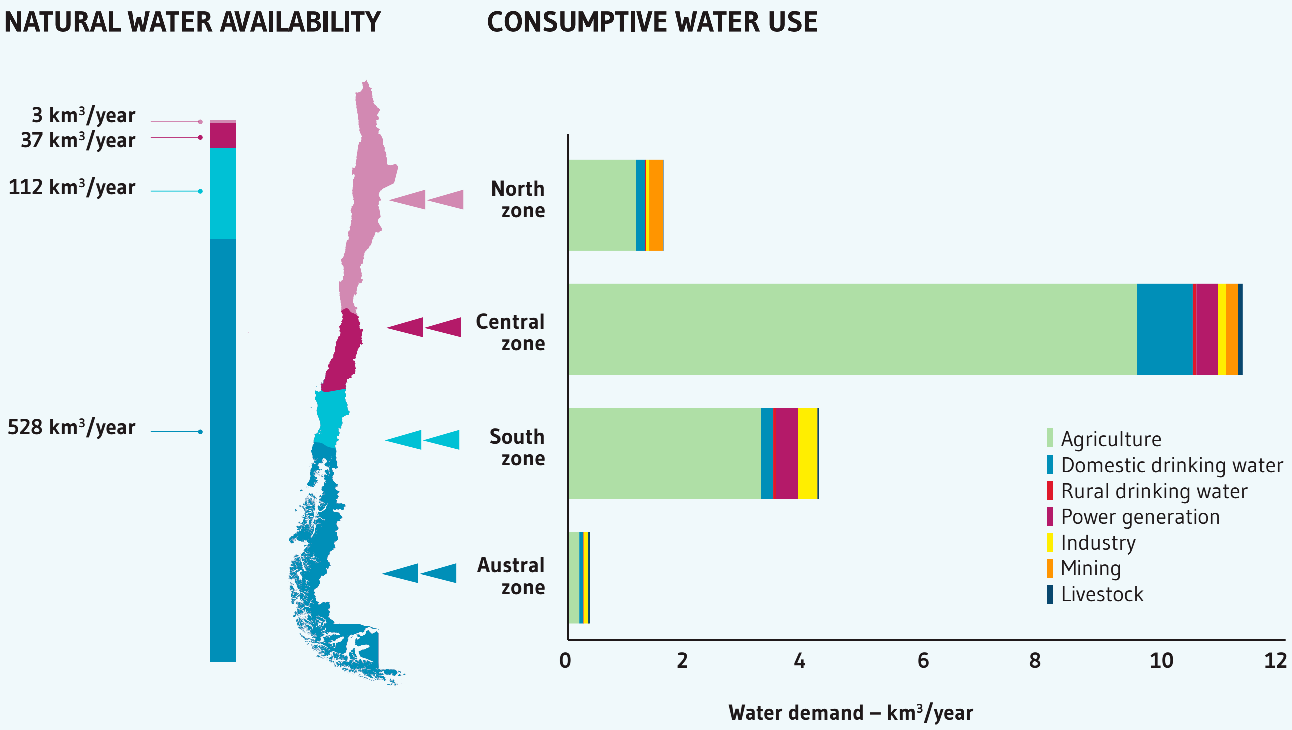
Legislative efforts are underway to address this potential. In particular, Bill No. 17.329-09, seeks to establish a specific legal framework for the reuse of treated wastewater currently discharged through submarine emissaries.

3.2 Water Availability and Competing Uses

3.2.1 Natural Water Availability and Water Uses

Water availability in Chile is highly uneven, reflecting the country's pronounced latitudinal and altitudinal diversity and the resulting wide range of climatic conditions and precipitation patterns. On average, Chile has a total natural water availability of approximately 680 km³ per year, representing the total volume of water generated annually by the hydrological cycle. While this figure is comparatively high by international standards, it conceals marked regional disparities and does not capture spatial mismatches between water supply and demand. In practice, water availability is extremely limited in the northern regions, which are characterised by arid and hyper-arid conditions, and increases progressively towards the south. As shown in **Figure 5** (below), the austral zone concentrates more than 75% of the country's total natural water availability, whereas northern regions account for less than 1% (Álvarez Garretón et al., 2023; Global Water Partnership, 2022).

Figure 5.
Territorial Distribution of Natural Water Availability and Consumptive Water Use in Chile per Year



Source: Own elaboration based on data from Álvarez Garretón et al.(2023), HIDRICA Consultores (2025)

Total water abstraction in Chile is estimated at approximately 107 km^3 per year, of which around 85% corresponds to non-consumptive uses, primarily associated with hydroelectric power generation. The remaining share, approximately 17 km^3 per year, corresponds to consumptive water use. As shown in **Figure 5** (right), agriculture accounts for the majority of consumptive water demand (approx. 81%), making it by far the dominant use. Drinking water systems represent the second largest consumptive use, accounting for approx. 9% of total demand, the majority of which corresponds to domestic water supply. Although average domestic consumption is around 145 liters per person per day in Chile, exceeding international reference averages, significant territorial disparities persist, including areas facing severe water supply constraints. Other sectors account for a comparatively small share of national consumptive water use, including thermal power generation (4%), industry (3%), mining (3%), and livestock (1%). Nevertheless, while these sectors represent a minor share of total national demand, they may be locally significant or even dominant at the basin or municipal level (Álvarez Garretón et al., 2023; HIDRICA Consultores, 2025).

3.2.2 Water Security Challenges

According to the inventory of the National Water Bank (*Banco Nacional de Aguas, BNA*) of the DGA, Chile comprises 101 basins, encompassing both surface and groundwater systems. At the national level, consumptive DAAs amount to approximately 31 km^3 per year. Estimated actual water use is lower than the volumes authorised under existing water rights, indicating that the total amount of water legally available for extraction exceeds current levels of use (Álvarez Garretón et al., 2023). However, this apparent balance at the national scale conceals pronounced constrains at the basin level, where the relationship between availability, allocation, and demand is considerably tighter. Within the framework of the *Long-Term Water Infrastructure Needs Assessment 2025–2055* conducted by the MOP, around 40% of Chilean basins have been officially declared in critical condition . This designation is based on a multicriteria assessment combining indicators of population pressure, hydrological balance, and water security gaps, and reflects structural water security deficits, where available water resources and infrastructure are insufficient to reliably meet current and projected demands (HIDRICA Consultores, 2025).

Around 40% of Chilean basins have been officially declared in critical condition, reflecting structural water security deficits where available resources and infrastructure are insufficient to meet current and projected demands.

Water scarcity pressures are most acute in the northern and central macro-zones. In northern Chile, limited naturally water availability, is compounded by agricultural and drinking water demand, as well as by significant water consumption by the mining sector. More than half of the basins in this macro-zone have been officially declared in critical condition. In several cases, total water requirements exceed the volumes effectively available under existing DAAs, leading activities such as mining to rely increasingly on desalination as an alternative supply source. The situation is particularly severe in the regions of Atacama, Antofagasta, and Tarapacá, where agro-industrial activities depend on water resources undergoing accelerated depletion, especially groundwater. These pressures are further intensified by water contamination and insufficient treatment systems, which have increased the incidence of waterborne diseases, especially in rural communities (Álvarez Garretón et al., 2023; HIDRICA Consultores, 2025).

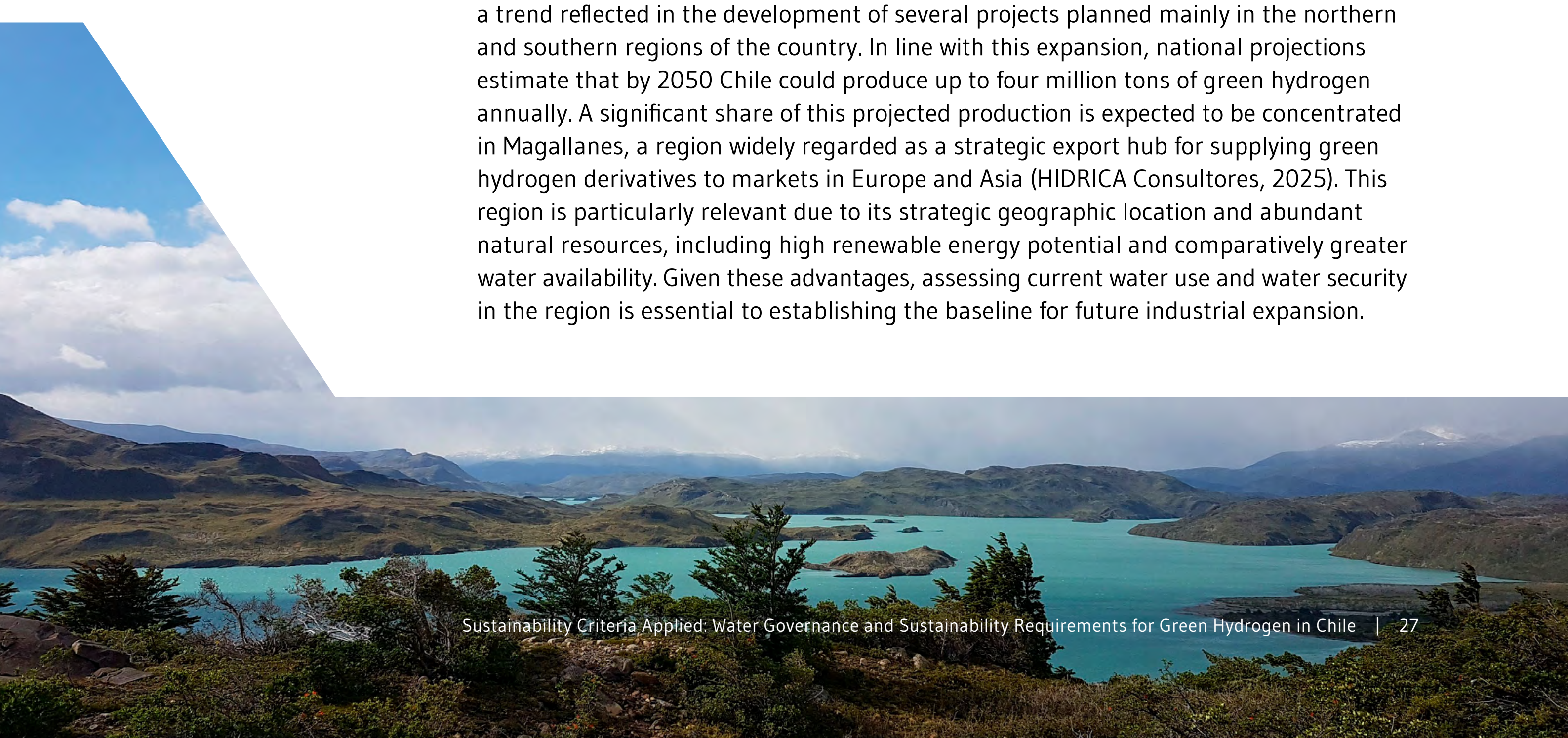
In central Chile, where a large share of the national population is concentrated, water demand is driven primarily by the intensive agricultural sector and high levels of domestic water consumption. The expansion of export-oriented fruit cultivation in regions such as O’Higgins and Maule has further increased irrigation demand, reinforcing pressure on already stressed basins. As a result, 11 of the 16 basins in this macro-zone have been declared in critical condition, with increasing water constraints giving rise to conflicts over DAAs (HIDRICA Consultores, 2025).

Although the southern and austral regions benefit from significantly higher levels of natural water availability, some basins in these regions have also been classified as critical. In addition, important gaps in sanitation coverage gaps persist, particularly in rural southern communities. More broadly, water security challenges in Chile exacerbate existing social inequalities, disproportionately affecting rural and peri-urban populations and generating growing territorial tensions over access to water. These dynamics highlight that Chile’s water crisis is not solely a question of overall water availability, but of spatial distribution, sectoral pressures, basin-level stress, and unequal access to basic services (Álvarez Garretón et al., 2023; HIDRICA Consultores, 2025).

Over the past four decades, Chile has experienced an unprecedented mega-drought, particularly pronounced since 2010. This period has been characterised by persistent precipitation deficits and a substantial reduction in surface water availability across most basins, with the phenomenon being especially severe in central and north-central Chile. Although the future persistence of the mega-drought remains uncertain, there is broad agreement that even if precipitation levels recover, many basins and communities will remain vulnerable for years due to depleted aquifers, reduced snowpack and glacier mass, and long-term ecosystem impacts. Evidence suggests that this prolonged drought reflects a combination of natural climate variability and anthropogenic climate change, with projections indicating that increasing aridity and reduced water availability, are likely to intensify, particularly in central Chile (Álvarez Garretón et al., 2023; Vicuña et al., 2022).

3.2.3 Focus Region: Magallanes and Chilean Antarctica

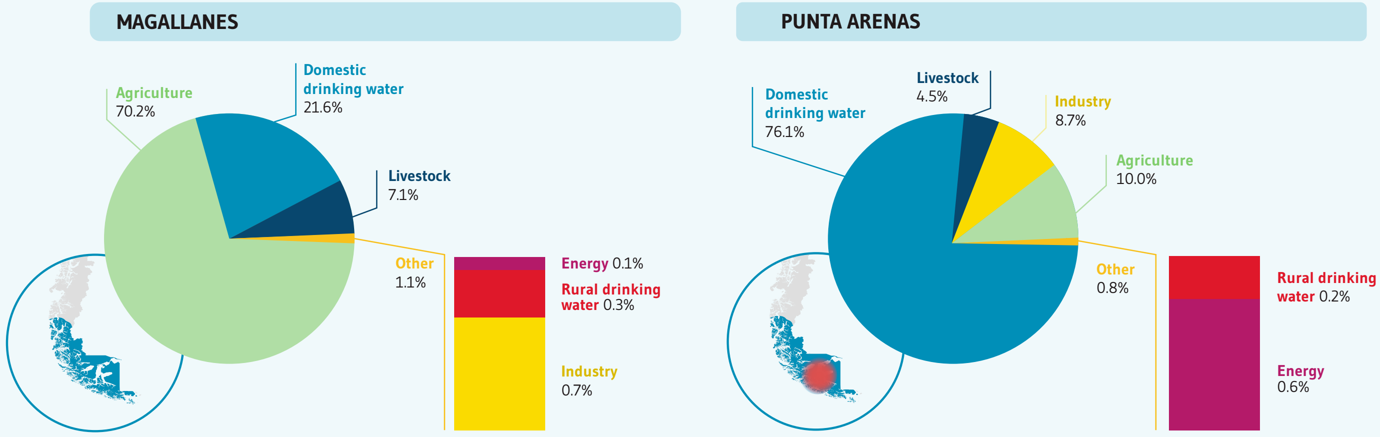
The green hydrogen industry is emerging as a central pillar of Chile’s economic strategy, a trend reflected in the development of several projects planned mainly in the northern and southern regions of the country. In line with this expansion, national projections estimate that by 2050 Chile could produce up to four million tons of green hydrogen annually. A significant share of this projected production is expected to be concentrated in Magallanes, a region widely regarded as a strategic export hub for supplying green hydrogen derivatives to markets in Europe and Asia (HIDRICA Consultores, 2025). This region is particularly relevant due to its strategic geographic location and abundant natural resources, including high renewable energy potential and comparatively greater water availability. Given these advantages, assessing current water use and water security in the region is essential to establishing the baseline for future industrial expansion.



3.2.3.1 Regional Water Use

The Magallanes Region is located in the austral zone of Chile and is characterised by significantly lower levels of consumptive water use across all sectors compared to other regions of the country (see **Figure 5**). This pattern reflects its low population density, limited urban development, and comparatively smaller scale of economic activity. As shown in **Figure 6**, agriculture represents the largest share of water demand in Magallanes, followed by domestic drinking water use and livestock activities. Other uses, including industry, rural drinking water supply, and energy generation, together account for only a minor share of total demand, estimated at around 1%.

Figure 6.
Sectoral Distribution of Consumptive Water Use in the Magallanes Region and Punta Arenas



Source: Own elaboration based on data from HIDRICA Consultores (2025)

In Punta Arenas, the capital of the Magallanes Region and home to approx. 80% of the regional population, water consumption is primarily associated with domestic drinking water supply. This is followed by livestock activities and aquaculture with approx. 15%, and industrial water use with about 9%. Although Punta Arenas exhibits a high level of domestic water service provision, with 95% of its population living in urban areas and 100% coverage of drinking water supply in these zones, substantial disparities persist at the regional level. The remaining population, located in rural areas, shows significantly lower access to safe drinking water, with only around 20% of rural inhabitants having access to potable water. This translates into approximately 6,000 people without access to drinking water, highlighting a critical regional challenge that disproportionately affects rural communities (Congreso Nacional de Chile, 2025; Fernández and Gironás, 2021).

Despite being commonly perceived as a water-abundant region, Magallanes exhibits structural vulnerabilities across its hydrographic basins.

3.2.3.2 Basin Hydric Stress

The Magallanes Region comprises 10 hydrographic basins, subdivided into 83 sub-basins and 244 sub-sub-basins. According to the MOP, two basins have been classified as critical: the Puerto Natales basin (BNA 122; *Costeras entre Seno Andrew, Río Hollemberg e islas al oriente*) and the Punta Arenas basin (BNA 125; *Costeras entre Laguna Blanca, Seno Otway, Canal Jerónimo y Estrecho de Magallanes*). Their critical status reflects the combined effect of structural gaps in water resource management and unfavourable water balance conditions, resulting in hydric stress driven by a mismatch between water availability and current demand. In addition, groundwater resources in these basins fall into two categories: restriction zones, where there is a serious risk of groundwater level decline affecting existing DAAs and aquifer sustainability, and prohibition zones, where groundwater availability is fully committed and no new DAAs can be granted (HIDRICA Consultores, 2025).

Focusing on the Punta Arenas basin, approximately 63% of its sub-basins exhibit a negative water security balance. A negative value indicates that available water supply is insufficient to meet total identified demands within the basin, including environmental flow requirements. At the annual scale, a substantial number of Punta Arenas sub-basins fall into this classification, while monthly assessments indicate that many remain under structural water imbalance throughout most of the year. Projections further suggest that hydric stress in the basin is likely to intensify in the coming years (Escenarios Hídricos 2030-EH2030, 2024).

Although some sub-basins within the Punta Arenas basin still present annual water surpluses, they experience critical conditions during the austral summer months. Spatially, the southern sector shows the most pronounced seasonal variability, with particularly critical values observed between April and September. By contrast, the northern sector exhibits greater structural vulnerability due to substantially lower precipitation. In urban areas, particularly within the commune of Punta Arenas, hydric stress is projected to extend beyond the summer season into autumn and winter, indicating a progressive deterioration in water availability (Escenarios Hídricos 2030-EH2030, 2024).

3.2.3.3 Structural Water Security Gaps

Despite being commonly perceived as a water-abundant region, Magallanes exhibits structural vulnerabilities across its hydrographic basins. Beyond the hydric stress identified in key basins, persistent information gaps constrain effective water governance. These including insufficient hydrogeological data, incomplete records on sanitation coverage and rural supply, limited knowledge of groundwater availability in aquifers, and the absence of a comprehensive and updated registry of extreme events such as droughts and floods. In parallel, deficiencies in the monitoring, operation, and management of water storage infrastructure further limit strategic planning and sustainable resource allocation (HIDRICA Consultores, 2025).

Water security challenges are particularly pronounced in rural areas, where deficits in drinking water and sanitation coverage increase social vulnerability. Multipurpose water infrastructure remains limited, restricting flexibility in responding to seasonal variability and emerging demands. Water quality is a significant concern across all basins, driven in part by agrochemical use in agricultural and livestock, as well as aquaculture. Water quality deterioration is further aggravated by insufficient sanitation coverage and the lack of adequate wastewater treatment systems. Moreover, more than half of the basins exhibit high vulnerability to extreme events such as floods, while flood protection infrastructure along rivers remains inadequate (HIDRICA Consultores, 2025).

Taken together, these conditions reveal that Magallanes’ apparent water availability does not necessarily translate into robust water security. Addressing these structural gaps through enhanced governance, strategic infrastructure planning, and integrated basin management will be essential to securing the region’s water future in the context of expanding socioeconomic and industrial development, particularly under the emerging PtX economy.

> Focusing on the Punta Arenas basin, approximately 63% of its sub-basins exhibit a negative water security balance. A negative value indicates that available water supply is insufficient to meet total identified demands within the basin, including environmental flow requirements.

3.3 Status of Desalination and Water Infrastructure Relevant to H_2

Green hydrogen has been positioned as one of Chile's principal long-term economic development strategies. Through the National Green Hydrogen Strategy, the country aims to establish itself as a global hub for the production of green hydrogen and its derivatives. However, hydrogen production via electrolysis requires significant volumes of water, raising questions regarding the sustainability of water supply in a context of existing water scarcity and competing demand.

In Chile, water resources are primarily allocated to human consumption and agriculture, which are both legally prioritized and socially sensitive uses. To avoid direct competition with these sectors, the emerging green hydrogen industry has increasingly turned to desalinated seawater as an alternative supply source (HIDRICA Consultores, 2025). Current projections suggest that the majority of the green hydrogen production in Chile is expected to rely on seawater desalination as the primary input for electrolysis (Abarca del Río et al., 2021). This orientation is further reinforced by the Government of Chile's *Green Hydrogen Action Plan*, presented by the Ministry of Energy, which explicitly promotes the development of an enabling regulatory framework for seawater desalination to support hydrogen production (Gobierno de Chile, 2024b).

3.3.1 Current Status of Desalination

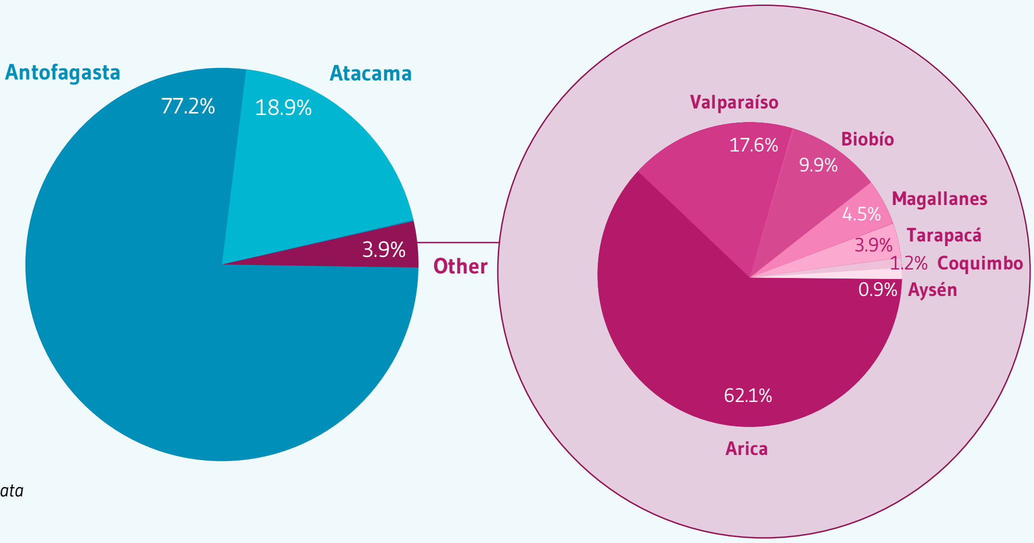
Chile's desalination sector has expanded rapidly over the past two decades, positioning the country as the largest installed desalination capacity in Latin America. This expansion was initially driven by the mining sector, particularly in response to groundwater overexploitation and increasing restrictions on freshwater abstraction in northern Chile. Desalination in Chile is predominantly based on reverse osmosis, which has proven to be the most energy-efficient and cost-effective technology currently available (Servicio de Evaluación Ambiental, 2023).

In the northern macro-zone, especially in the regions of Antofagasta and Atacama, desalination plants were developed to secure water supply for mining operations while reducing pressure on continental freshwater sources and avoiding competition with domestic water use. Over time, desalination has evolved from a sector-specific solution into a central component of broader regional water supply strategies. Its integration into urban systems has helped mitigate the impacts of prolonged drought, reduced dependence on traditional freshwater sources, and simultaneously secured water supply for industrial activities. As a result, desalination infrastructure is increasingly framed as a structural response to persistent water scarcity, rather than as a temporary or marginal supply option (HIDRICA Consultores, 2025).

> Chile's desalination sector has expanded rapidly over the past two decades, positioning the country as the largest installed desalination capacity in Latin America.

As shown in **Figure 7**, approximately 77% of Chile's installed desalination capacity is concentrated in the Antofagasta region, followed by 19% in Atacama. The remaining 4% is distributed mainly across Arica and Valparaíso, with smaller shares in Biobío, Magallanes, Tarapacá, Coquimbo, and Aysén. At the national level, desalination activity therefore remains predominantly concentrated in northern Chile (Vicuña et al., 2022).

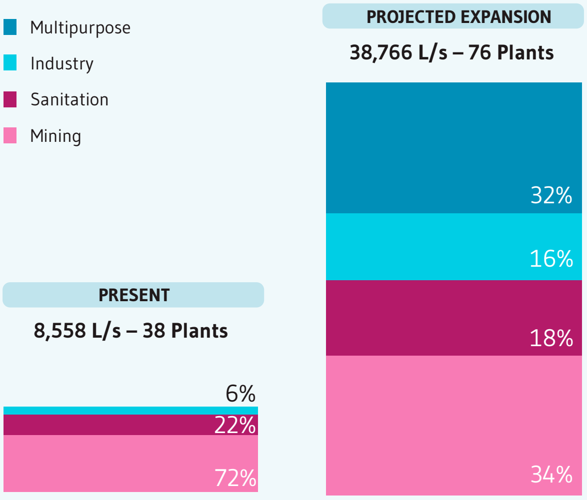
Figure 7.
Regional Distribution of Installed Desalination Capacity in Chile



Source: Own elaboration based on data from Vicuña et al., (2022).

This geographical concentration reflects the dominant role of the mining sector in driving desalinated water demand. As illustrated in **Figure 8** (left), current national desalination capacity exceeds 8,500 L/s of desalinated seawater production, distributed across 38 operational plants. More than 70% of this capacity is allocated to the mining sector, with the remainder divided between sanitation services and industrial uses, including thermoelectric power generation (Green I&C, 2023; Vicuña et al., 2022).

Figure 8.
Current and Projected Installed Desalination Capacity by Sector in Chile



Source: Own elaboration based on data from Vicuña et al. (2022)

In addition to existing capacity, 38 new desalination projects and plant expansions have been announced and are currently under development. If completed, total operational capacity would increase more than fourfold, exceeding 38,700 L/s across 76 plants, as shown in **Figure 8** (right). Under this expansion scenario, the largest absolute increase would come from multipurpose projects, contributing an additional 12,250 L/s. These multipurpose plants are designed to supply desalinated water for range of uses, including human consumption, industrial processes, irrigation, livestock, agriculture, and electrolysis for hydrogen production. Additional capacity is projected for mining (7,210 L/s), industrial uses (5,868 L/s), and sanitation services (4,880 L/s). Notably, the relative increase in capacity allocated to industrial uses represents more than a fourteen-fold expansion (Vicuña et al., 2022).

Although individual project timelines vary, current projections indicate that national desalination capacity could reach approximately 14,800 L/s by 2030, corresponding to an increase of nearly 98% compared to current operational levels (Green I&C, 2023). From a sectoral perspective, mining-related expansion remains primarily concentrated in Antofagasta and Atacama, reinforcing the predominance of northern Chile in desalinated water use for mining. In contrast, sanitation-related capacity increases are more geographically disperse, with a notable expansion projected in Coquimbo (Vicuña et al., 2022). Overall, projected desalination expansion remains geographically concentrated in northern Chile. Industrial capacity growth is led by projects in Atacama, while multipurpose desalination is concentrated in Antofagasta and extends into selected central regions such as Coquimbo and Valparaíso, reinforcing the northern dominance of desalination development at the national level (Vicuña et al., 2022).

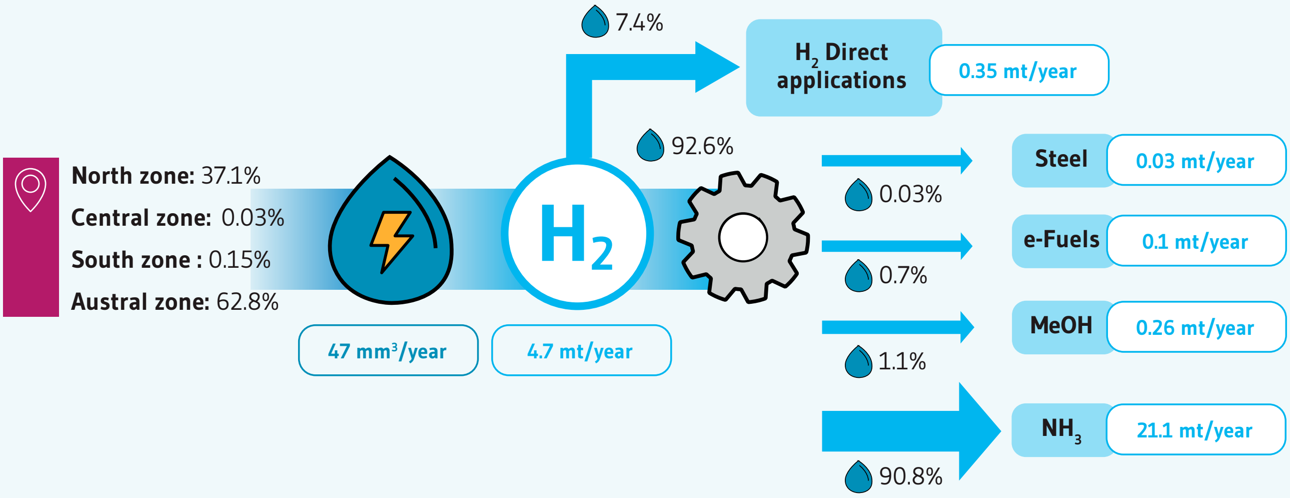
3.3.2 Projected Green Hydrogen Production and Water Demand

According to the *Chilean Hydrogen Association–H_2* Chile, as of December 2025 a total of 83 green hydrogen-related projects have been announced nationwide. Of these, 46 correspond to hydrogen and derivative production and commercialization, 33 involve hydrogen use across different applications, and 4 concern manufacturing activities within the value chain (Asociación Chilena de Hidrógeno-H2Chile, 2025). From this total, 50 projects were selected for analysis, as they provide publicly available quantitative information on projected hydrogen production, derivative output, or installed electrolysis capacity. While the level of detail varies across projects, available information made it possible to estimate hydrogen output and associated water requirements for all cases.

Based on the 50 projects analysed, Chile is projected to reach an annual production of approximately 4.7 million tonnes of green hydrogen.

Based on the 50 projects analysed, Chile is projected to reach an annual production of approximately 4.7 million tonnes of green hydrogen (H_2). Achieving this level of output would require a minimum annual water consumption of around 47 million cubic metres, as illustrated in **Figure 9**. This estimate is based on a baseline requirement of 10 kilograms of water per kilogram of hydrogen, representing the minimum input to the electrolyser. This value is derived from the theoretical stoichiometric demand of approximately 9 kilograms of UPW per kilogram of hydrogen plus an additional 10% to account for system inefficiencies and process losses. However, actual water consumption may be significantly higher due to additional operational requirements, particularly cooling for the electrolyser, which represents the largest source of uncertainty in overall water demand estimates. Cooling alone can contribute additional water consumption ranging from negligible levels up to approximately 25 litres per kilogram of hydrogen, depending on the electrolyser technology, its associated efficiency, and the cooling strategy employed.

Figure 9.
Projected Green Hydrogen Value Chain and Associated Water Demand in Chile



Source: Own elaboration based on data from Asociación Chilena de Hidrógeno-H2Chile (2025)

At present, only six of these projects are operational and producing hydrogen. These correspond to small-scale initiatives or pilot plants, with a combined annual output of approximately 255 tonnes, representing less than 0.01% of total projected production. Consequently, the estimated 4.7 million tonnes largely reflect anticipated future capacity rather than current operational output. Beyond the plants already in operation, most of the announced projects remain at early stages of development, predominantly at pre-feasibility or feasibility studies, with only a limited number having entered the environmental assessment phase.

The timeline for reaching the projected production levels remains uncertain, as not all projects have disclosed their expected start dates. However, approximately 30 projects indicate an intended start of operations by 2030. Based on this subset, Chile could potentially reach an annual production of around 2.8 million tonnes of green hydrogen by 2030, corresponding to a minimum water consumption of approximately 28 million cubic metres per year. In addition, official sources estimate that by 2050 Chile could produce up to four million tonnes of green hydrogen annually, which may therefore be considered a relevant long-term time horizon for assessing future water demand (HIDRICA Consultores, 2025).

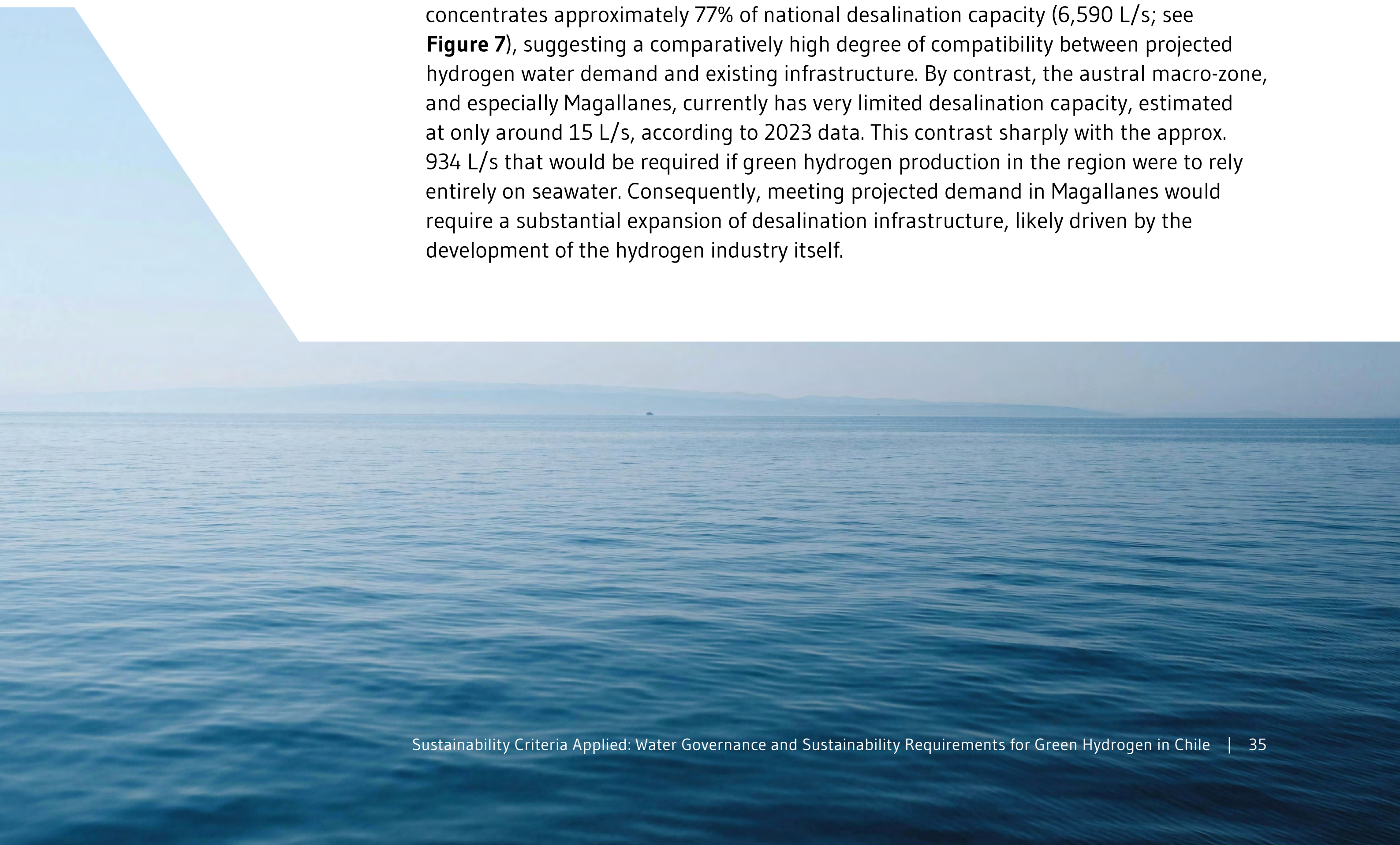
As shown in **Figure 9**, more than 90% of projected green hydrogen production is expected to be converted into derivatives, primarily green ammonia (NH_3). Current announcements indicate planned ammonia production of approximately 21.1 million tonnes, driven largely by large-scale, export-oriented projects concentrated in the Magallanes region, which alone accounts for nearly 70% of projected output. The remaining share is concentrated mainly in Antofagasta, where projects are similarly oriented toward export markets, with only limited volumes allocated to domestic demand.

Other derivatives, including methanol (MeOH) and e-fuels, are associated with a smaller number of projects, generally at small- to medium-scale. Announced production capacities range from approximately 300 to 200,000 tonnes of derivative per year, with e-fuels projects primarily located in the Magallanes, and methanol projects in Antofagasta. In addition, a green steel project has been announced in the Biobío region, with an expected production capacity of around 25,000 tonnes per year. Approximately 7% of the projected green hydrogen production is expected to be used in direct applications, mainly mobility and electricity generation, and largely intended to meet domestic demand. These projects are located primarily in the Antofagasta, with smaller-scale initiatives distributed across Aysén, Ñuble, Coquimbo, the Metropolitan Region, Biobío, and Valparaíso.

Taken together, the northern and austral macro-zones, represented mainly by Antofagasta and Magallanes, emerge as the core hubs of Chile's developing green hydrogen value chain. This geographical distribution has direct implications for regional water demand. Of the total water projected to be required for hydrogen production, approximately 63% is expected to be extracted in the austral macro-zone, while the remaining 37% would be extracted in the northern.

In light of the water security constraints described in the previous sections, the ongoing expansion of desalination in Chile, and the explicit policy orientation promoting its use for green hydrogen, future hydrogen production in both macro-zones in likely to rely predominantly on seawater. The projected minimum annual water demand of 47 million cubic metres per year corresponds to approximately 1,488 L/s, equivalent to around 17% of Chile's current installed desalination capacity (8,558 L/s; see **Figure 8**), even before accounting for the significant expansion planned in the sector.

At the regional level, the northern macro-zone, particularly Antofagasta, already concentrates approximately 77% of national desalination capacity (6,590 L/s; see **Figure 7**), suggesting a comparatively high degree of compatibility between projected hydrogen water demand and existing infrastructure. By contrast, the austral macro-zone, and especially Magallanes, currently has very limited desalination capacity, estimated at only around 15 L/s, according to 2023 data. This contrast sharply with the approx. 934 L/s that would be required if green hydrogen production in the region were to rely entirely on seawater. Consequently, meeting projected demand in Magallanes would require a substantial expansion of desalination infrastructure, likely driven by the development of the hydrogen industry itself.



3.4 Chile's Water Context in Emerging International PtX Value Chains

Chile's water context, as outlined in this chapter, reflects the interaction between resource availability, institutional governance, and the projected expansion of PtX production. Although part of the expected output will serve domestic applications, the sector is largely oriented towards export markets. In this context, the combined effects of these factors are not only relevant at the national level but are also closely linked to Chile's position within emerging international hydrogen value chains.

Chile's integration into this emerging international hydrogen economy is already taking shape through a combination of trade-oriented policy frameworks, strategic partnerships, public financial support, and private sector engagement. At the policy level, cooperation with the EU has intensified through the recent entry into force of the EU–Chile Interim Trade Agreement and the broader Advanced Framework Agreement, which deepen bilateral trade, investment, and cooperation on sustainable development. This builds on an already strong economic relationship, with the EU as Chile's third-largest trading partner. Within this framework, energy and climate-related collaboration, including green hydrogen, is increasingly positioned as a strategic area of engagement, reflecting Europe's growing interest in securing international supply chains to support its decarbonisation objectives. Through its Global Gateway Investment Agenda, the EU is supporting Chile with targeted initiatives in renewable hydrogen production, further reinforcing this strategic partnership (European Commission, 2025).

This political alignment is further complemented by financial support through the creation of the Team Europe Renewable Hydrogen Funding Platform for Chile, established by the European Union in cooperation with the European Investment Bank (EIB), KfW Development Bank, and the EU Latin America and Caribbean Investment Facility. The initiative mobilises up to €216 million to support Chile's energy transition by increasing renewable electricity generation and electrolyser capacity (European External Action Service, 2025).

> Chile's integration into this emerging international hydrogen economy is already taking shape through a combination of trade-oriented policy frameworks, strategic partnerships, public financial support, and private sector engagement.

At the project level, European actors play a direct role in the development of green hydrogen and derivative production facilities. It is estimated that at least 45% of the projected 4.7 million tonnes of green hydrogen production in Chile (see Section 3.3.2) involves EU companies, including roles as project developers, investors, and industrial partners. Several representative large-scale projects illustrate this involvement.

The H2 Magallanes project, led by TotalEnergies H2 (France), is expected to produce approximately 1.9 million tonnes of green ammonia per year. In addition, the Energía Verde Austral and Punta Delgada projects, developed by EDF Power Solutions and EDF Renewables (France), respectively, are planned to deliver a combined production capacity of around 1.5 million tonnes of green ammonia annually. Furthermore, the Frontera project, involving Nordex Energy (Germany), is expected to produce approximately 1 million tonnes of green ammonia per year. Beyond France and Germany, other European countries are also involved in the development of PtX projects in Chile, including Austria, Norway, and Spain, through companies such as Austria Energy and Ökowind (Austria), Statkraft (Norway), as well as Acciona and Enagás (Spain), reflecting the broader European participation in the sector (Asociación Chilena de Hidrógeno-H_2Chile, 2025).

Taken together, these developments indicate that Chile’s water governance can be increasingly shaped by external actors. As PtX production scales, water management practices will be evaluated against both national priorities and the expectations of international partners and markets. In this context, international frameworks, particularly those within the European Union, become a critical reference point for assessing the robustness of Chile’s water sustainability approach in the development of green hydrogen value chains.

Building on this, the following section examines how water-related sustainability considerations are defined within relevant international frameworks for green hydrogen, with a particular focus on the European Union. This provides the basis for the subsequent assessment of how these criteria align with Chile’s existing water governance and regulatory context.

Taken together, these developments indicate that Chile’s water governance can be increasingly shaped by external actors. As PtX production scales, water management practices will be evaluated against both national priorities and the expectations of international partners and markets.

4

LANDSCAPE OF WATER-RELATED SUSTAINABILITY CRITERIA FOR GREEN HYDROGEN

This section examines how water-related sustainability considerations are currently addressed within EU and international existing frameworks relevant to green hydrogen production. As hydrogen trade expands across borders, sustainability expectations increasingly shape market access, certification, and investment decisions. Understanding how water sustainability is defined and implemented in these frameworks is therefore essential for evaluating potential alignment in exporting countries.

The section provides a structured overview of recurring water-related sustainability criteria and analyses how they are embedded in EU policy instruments, regulatory frameworks, certification schemes, and relevant research and policy-oriented literature. While EU instruments represent some of the most operationalised and widely referenced frameworks for hydrogen trade, they are used here as indicative benchmarks rather than exclusive standards.

The objective is to establish a coherent analytical basis for assessing the adequacy and consistency of existing approaches and their subsequent comparison with Chile’s water governance and regulatory context. By identifying common criteria and examining their treatment across different instruments, this section lays the foundation for assessing areas of alignment, misalignment, and potential regulatory gaps in the context of international green hydrogen value chains.

Section 4.1 first identifies recurring water-related sustainability criteria

Section 4.2 places these criteria within key EU and international frameworks

Section 4.3 concludes with a synthesis of insights derived from this analysis.

As hydrogen trade expands across borders, sustainability expectations increasingly shape market access, certification, and investment decisions. Understanding how water sustainability is defined and implemented in these frameworks is therefore essential for evaluating potential alignment in exporting countries.

4.1 Recurring Water-Related Criteria

Water is a central input to green hydrogen production, yet the way water-related sustainability is defined and assessed varies widely existing frameworks. This subsection therefore brings together recurring water-related sustainability criteria identified through a systematic review of policy instruments, regulations, certification schemes, and relevant research and policy-oriented literature, with the aim of making these approaches comparable.

The criteria were derived inductively through document analysis, based on their recurrence across sources, thematic affinity, and substantive focus. They are grouped into indicative water-related clusters based on thematic proximity and functional similarity. This clustering approach serves as an analytical tool to structure comparison across different instruments and to support later assessment against national regulatory contexts in Chile. The resulting clusters provide a consistent reference point for analysing how water sustainability is addressed across diverse frameworks.

› **Water source transparency and documentation**
Expectations related to the clear identification, documentation, and justification of water sources used for hydrogen production. This includes distinctions between surface water, groundwater, desalinated seawater, treated wastewater, and drinking water, as well as disclosure of water volumes, availability, and baseline water stress conditions.

› **Water-use efficiency and minimisation**
Expectations concerning the efficient use of water throughout hydrogen production and associated processes. This may include qualitative or quantitative references to minimising water consumption, reducing losses, improving efficiency, or monitoring water use over time, without necessarily defining binding thresholds.

› **Avoidance of competition with drinking water and essential local uses**
Expectations related to avoiding adverse impacts on access to water for human consumption, agriculture, food security, and other essential local uses. This includes references to water rights, prioritisation of local needs, and the prevention of water-related conflicts.

› **Governance, permitting, and stakeholder participation**
Procedural expectations related to how water-related risks are assessed and managed. This includes environmental impact assessments, water management plans, permitting requirements, stakeholder consultation, public reporting, and mechanisms to address grievances or water rights concerns.

› **Environmentally responsible desalination and discharge**
Expectations specific to the use of seawater desalination, including the management of brine and other effluents, intake and discharge design, protection of marine and coastal ecosystems, and the avoidance of negative downstream environmental effects.

› **Long-term water sustainability and cumulative impacts**
References to the long-term availability of water resources over the lifetime of hydrogen projects, including cumulative impacts, climate change effects, and the ability to demonstrate sustained water security beyond short-term project needs.

4.2 Overview of Key Frameworks

This subsection draws on a set of EU and international documents identified through a broader screening of texts related to green hydrogen production. While the overview is not exhaustive, the selection reflects a deliberate focus on EU-level and international instruments that are intended to shape sustainability expectations across borders, rather than on national frameworks inside or outside the EU, which operate under distinct regulatory and certification regimes.

The analysed documents differ not only in thematic scope but also in their legal character and degree of bindingness, which influences their practical impact. Commission Communications are non-binding instruments that articulate policy positions, guidance, or strategic orientations (European Union, 2024). Directives are binding as to the objective to be achieved but leave discretion to Member States regarding transposition into national law. EU Regulations, by contrast, are directly applicable and binding in all Member States, requiring uniform implementation (European Union, n.d.). Voluntary certification schemes operate outside formal legislation, relying on third-party conformity assessment to demonstrate compliance with defined standards (ISO, n.d.). Understanding these distinctions is essential, as the level of legal force shapes how water-related sustainability criteria translate into actual conduct, enforcement, and market expectations.

A total of 35 texts related to green hydrogen were identified and are listed in the appendix (Table 9). From this broader set, 16 documents were selected for detailed analysis, reflecting a focus on European Union–level and international instruments relevant to water-related sustainability criteria. **Table 2** provides an overview of the number of analysed documents by instrument type. The selected documents are classified by instrument type, including Communications (**Section 4.2.1**), Directives (**Section 4.2.2**), Regulations (**Section 4.2.3**), Voluntary Certification Schemes (**Section 4.2.4**), and relevant Research and Policy-oriented Literature (**Section 4.2.4**). For each document, the overview describes its scope and relevance to green hydrogen, its treatment of water-related sustainability aspects, and its linkage to the indicative water-related criteria identified in Section 3.1.

By situating the recurring criteria within concrete governance and certification frameworks, this subsection provides the empirical basis for identifying patterns, gaps, and inconsistencies in how water sustainability is currently implemented.

Table 2.
Number of documents analysed by instrument type

TYPE OF DOCUMENTS	COMMUNICATIONS	DIRECTIVES	REGULATIONS	VOLUNTARY CERTIFICATION SCHEMES	RESEARCH AND POLICY-ORIENTED LITERATURE
NUMBER OF DOCUMENTS	1	2	2	5	6

4.2.1 Document type: European Union Communication

At the end of this subsection, a summary table provides an overview of the documents discussed and indicates which recurring water-related sustainability criteria they address, as defined in Section 3.1.

4.2.1.1 Communication from the European Commission on the European Hydrogen Bank (COM/2023/156, 2023)

This Communication sets out the policy rationale, objectives and implementation approach of the European Hydrogen Bank[5], a financing and coordination instrument intended to accelerate the scale-up of renewable hydrogen production within the EU and internationally. The Hydrogen Bank aims to close the investment gap between renewable hydrogen supply and demand, supporting the EU objective of reaching 20 million tonnes of renewable hydrogen per year. While the Communication does not introduce legally binding requirements, it provides strategic guidance that shapes funding decisions, eligibility conditions and coordination with existing EU financial instruments.

The Communication is explicitly aligned with the RePowerEU[6] objectives, the Green Deal Industrial Plan[7] and the Net-Zero Industry Act[8], and accompanies legislative proposals under the EU's industrial and energy policy framework.

› How water is addressed in the Communication

Water considerations are framed primarily in relation to sustainability risks associated with scaling up renewable and low-carbon hydrogen production. The Communication acknowledges that additional freshwater demand may arise from expanded hydrogen production capacity and emphasises the importance of compliance with existing EU water legislation, in particular the Water Framework Directive[9], at locations where new hydrogen production is deployed.

In the context of international hydrogen production, the Communication highlights the need to avoid increasing water stress and to prevent negative impacts on access to water and electricity in partner countries. Sustainability of renewable hydrogen production is explicitly linked to water availability, accessibility and management, particularly where EU financial support is provided through external action instruments.

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[5] (European Commission, n.d.)

[6] (European Commission, 2022)

[7] (Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic And Social Committee and the Committee of the Regions A Green Deal Industrial Plan for the Net-Zero Age, 2023)

[8] (Proposal for a Regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act), 2023)

[9] (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 2014)

› Water-related implications for funding and cooperation

The Communication establishes water sustainability as a relevant consideration for access to EU support mechanisms. For projects supported through Global Gateway and the Neighbourhood, Development and International Cooperation Instrument–Global Europe (NDICI-GE) (see subsection 4.2.3.2), one of the key preconditions is contribution to the domestic green transition, including sustainability and efficient use of resources for renewable hydrogen production. This explicitly includes water availability, accessibility and management as part of project eligibility considerations.

The Communication therefore positions water as a cross-cutting sustainability constraint that should be addressed through compliance with existing regulatory frameworks, project-level assessments and alignment with broader EU sustainability objectives, both within the EU and in partner countries.

› Indicative water criteria clusters

Within the proposed analytical framework, this Communication aligns primarily with *governance, permitting, and stakeholder participation*, through its reliance on existing EU legislation and funding conditionality, and with *long-term water sustainability and cumulative impacts*, given its focus on large-scale market development and international cooperation. It also implicitly supports *water source transparency and documentation and avoidance of competition with drinking water and essential local uses*, particularly in partner countries, by linking EU financial support to sustainable resource management. Direct requirements on *water-use efficiency and minimisation* and *environmentally responsible desalination and discharge* are not specified but are expected to be addressed through compliance with applicable regulatory and financing frameworks.

The table below summarises the documents discussed in this subsection and indicates which recurring water-related sustainability criteria they address.

Table 3.
Summary of documents and corresponding water-related sustainability criteria addressed in European Union Communications

DOCUMENT NAME	CRITERIA
COM/2023/156	Water source transparency and documentation
	Avoidance of competition with drinking water and essential local uses
	Governance, permitting, and stakeholder participation
	Long-term water sustainability and cumulative impacts

4.2.2 Document type: European Union Directive

At the end of this subsection, a summary table provides an overview of the documents discussed and indicates which recurring water-related sustainability criteria they address, as defined in Section 3.1.

4.2.2.1 Directive (EU) 2024/1760–Corporate Sustainability Due Diligence Directive (CSDDD) (Directive (EU) 2024/1760, 2024)

This Corporate Sustainability Due Diligence Directive (CSDDD) establishes a legally binding corporate due diligence duty for large EU and non-EU companies operating in the EU. Its objective is to ensure that companies identify, prevent, mitigate and address adverse human rights and environmental impacts arising from their own operations, those of their subsidiaries, and, where linked to their value chains, those of their business partners, both inside and outside the EU.

Unlike voluntary standards or policy communications, this Directive creates enforceable obligations that must be transposed into national law by Member States. Compliance is subject to administrative supervision by designated national authorities, including the possibility of injunctive measures and of dissuasive penalties (fines), and applies following a staggered implementation timeline once transposition is completed.

Although the Directive is not hydrogen-specific, it is highly relevant for green hydrogen projects and supply chains. In particular, hydrogen production, water abstraction, desalination, and associated infrastructure may give rise to environmental or social risks that fall within the scope of mandatory due diligence, including risks related to water pollution, excessive water consumption, impacts on access to drinking water, and degradation of ecosystems. As such, the Directive establishes a binding governance framework within which water-related risks linked to green hydrogen production must be identified, assessed, and addressed.

› Core due diligence obligations relevant to water

The Directive requires companies in scope to integrate due diligence into policies and management systems, identify and assess adverse environmental impacts across the life cycle of their activities, prevent or minimise such impacts, monitor effectiveness, communicate publicly, and provide remediation where harm occurs. Environmental due diligence is explicitly linked to avoiding environmental degradation that results in adverse health effects and to respecting the right to a clean, healthy and sustainable environment, in line with the 'One Health' approach, which is "*integrated, unifying approach to balance and optimize the health of people, animals and ecosystems*" (WHO, 2023).

Water-related impacts are directly covered through the definition of adverse environmental impacts, which includes harmful water pollution, excessive water consumption, and degradation of natural resources that may impair food production, deny access to safe drinking water or sanitation, or adversely affect ecosystem services.

› Explicit treatment of water in the Annex

The Annex to the Directive specifies prohibitions and obligations drawn from international human rights and environmental instruments. These include the prohibition of causing measurable environmental degradation through excessive water consumption or water pollution where this denies access to safe and clean drinking water, harms health or livelihoods, or substantially affects ecosystem services. The Directive also refers to obligations to avoid or minimise adverse impacts on wetlands and to prevent, reduce and control pollution of the marine environment, including by dumping.

Through these provisions, water use, water quality and water-dependent ecosystems become legally relevant elements of corporate due diligence, including for activities linked to hydrogen production and associated infrastructure.

› Indicative water criteria clusters

The CSDDD aligns strongly with *governance, permitting, and stakeholder participation*, through its mandatory due diligence and management system requirements, and with *avoidance of competition with drinking water and essential local uses*, given its explicit protection of access to safe drinking water and livelihoods. It also supports *long-term water sustainability and cumulative impacts*, as due diligence obligations extend across value chains and life-cycle stages. Elements related to *water source transparency and documentation* are implied through identification, assessment and reporting duties, while *water-use efficiency and minimisation and environmentally responsible desalination and discharge* are addressed indirectly via the obligation to prevent or minimise adverse environmental impacts.

4.2.2.2 Directive (EU) 2024/1619–Amendment of the Capital Requirements Directive (CRD) on ESG Risks (Directive (EU) 2024/1619, 2024)

This Directive amends Directive 2013/36/EU[10] (the Capital Requirements Directive) to strengthen supervisory powers and explicitly integrate environmental, social and governance (ESG) risks into the framework for credit institutions. Its objective is to ensure that banks and other regulated institutions systematically identify, manage and monitor ESG risks as sources of financial risk over short-, medium- and long-term horizons, with particular emphasis on forward-looking assessment.

The Directive requires institutions to incorporate ESG risks into their governance arrangements, risk management frameworks and planning, and empowers competent authorities to assess, monitor and, where necessary, intervene where ESG risks are insufficiently addressed. This includes the use of scenario analysis and resilience testing over long-term time horizons of at least ten years, based on credible, science-based scenarios developed by international organisations. Enforcement is carried out through supervision by competent national authorities, coordinated at EU level.

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[10] (Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC Text with EEA relevance, 2013)

Although this Directive does not regulate hydrogen production or water use directly, it is relevant for green hydrogen projects because it shapes how financial institutions assess and manage exposure to environmental risks, including water-related risks, associated with the projects and value chains they finance. As such, it influences access to finance for hydrogen projects that may entail material environmental risks, including water-related risks.

› Core ESG risk management obligations relevant to water

The Directive requires competent authorities to ensure that institutions have robust strategies, policies, processes and systems in place for the identification, measurement, management and monitoring of ESG risks. Environmental risks, including those arising from environmental degradation and biodiversity loss, are explicitly prioritised and are to be assessed over a long-term time horizon of at least ten years.

Water-related risks fall within this environmental risk category where they arise from physical impacts of climate change, environmental degradation or biodiversity loss, or from transition risks linked to regulatory and policy developments. Institutions are required to assess the alignment of their portfolios with the Union's climate neutrality objective and the avoidance of environmental degradation, which implicitly includes exposure to projects that may exacerbate water scarcity, water pollution or ecosystem impacts.

› Indicative water criteria clusters

This Directive aligns primarily with *long-term water sustainability and cumulative impacts*, given its emphasis on forward-looking risk assessment and long-term horizons, and with *governance, permitting, and stakeholder participation*, through its requirements for internal governance, strategies and supervisory oversight.

Water-related risks are addressed indirectly as part of broader environmental risk management obligations rather than through operational or technical water-use requirements. As a result, the Directive does not establish direct criteria related to water source transparency and documentation, *water-use efficiency and minimisation, or environmentally responsible desalination and discharge* at the project level.

The table below summarises the documents discussed in this subsection and indicates which recurring water-related sustainability criteria they address.

Table 4.
Summary of documents and corresponding water-related sustainability criteria addressed in European Union Directives

DOCUMENT NAME	CRITERIA
Directive (EU) 2024/1760	Avoidance of competition with drinking water and essential local uses
Directive (EU) 2024/1760	Environmentally responsible desalination and discharge
Directive (EU) 2024/1760; (EU) 2024/1619	Governance, permitting, and stakeholder participation
Directive (EU) 2024/1760; (EU) 2024/1619	Long-term water sustainability and cumulative impacts
Directive (EU) 2024/1760	Water source transparency and documentation
Directive (EU) 2024/1760	Water-use efficiency and minimisation

4.2.3 Document type: European Union Regulations

At the end of this subsection, a summary table provides an overview of the documents discussed and indicates which recurring water-related sustainability criteria they address, as defined in Section 3.1.

4.2.3.1 Regulation (EU) 2020/852–EU Taxonomy Regulation (Regulation (EU) 2020/852, 2020)

The EU Taxonomy Regulation establishes a common EU-wide framework for determining whether an economic activity qualifies as environmentally sustainable. Its objective is to provide a coherent and science-based classification system that supports sustainable investment by defining environmental objectives and setting conditions under which economic activities can be considered as making a substantial contribution to those objectives while avoiding significant harm to others.

EU Taxonomy explicitly recognises the systemic and interconnected nature of environmental challenges, including climate change, biodiversity loss, resource overconsumption and the deterioration of freshwater systems. It adopts a forward-looking approach to sustainability, embedding environmental protection within financial markets, public measures, standards and labels. While the Regulation is not sector-specific, it is directly relevant to green hydrogen activities, as it establishes binding criteria that influence how hydrogen-related projects are assessed, labelled and financed as environmentally sustainable within the EU.

› Core environmental objectives and treatment of water

EU Taxonomy defines six environmental objectives, one of which is the sustainable use and protection of water and marine resources. This objective is placed on equal footing with climate change mitigation and adaptation, pollution prevention and biodiversity protection, signalling the central role of water within the EU sustainability framework.

The sustainable use and protection of water and marine resources is to be interpreted in line with existing Union water legislation, including the Water Framework Directive[11], the Drinking Water Directive[12], the Urban Waste Water Treatment Directive[13], the Marine Strategy Framework Directive[14] and related policy communications on water scarcity, droughts and water quality. This anchors the Regulation firmly within the broader EU water framework.

An economic activity qualifies as making a substantial contribution to this water-related objective where it contributes to achieving or maintaining good status of surface water,

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[11] (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 2014)

[12] (Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast) (Text with EEA relevance), 2020)

[13] (Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast) (Text with EEA relevance), 2024)

[14] (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (Text with EEA relevance), 2017)

groundwater or marine waters, or prevents their deterioration. EU Taxonomy explicitly links sustainable water use to improved water management and efficiency, protection of aquatic ecosystems, reduction of pollutant emissions to water bodies, mitigation of floods and droughts, and protection of human health through access to clean drinking water. Activities related to wastewater collection, treatment and discharge, including emerging contaminants such as pharmaceuticals and microplastics, are also explicitly recognised.

› Substantial contribution and "do no significant harm" logic

Beyond water-specific objectives, EU Taxonomy establishes a broader architecture in which economic activities must both contribute substantially to at least one environmental objective and avoid causing significant harm to any of the others. This logic is implemented through delegated acts that define technical screening criteria for each objective, including water and marine resources.

For hydrogen production and related infrastructure, this means that activities may be assessed not only for their contribution to climate change mitigation, for example through renewable fuel production, but also for their impacts on water resources, pollution and ecosystems. EU Taxonomy thereby embeds water considerations within a cumulative sustainability assessment rather than treating them in isolation.

› Indicative water criteria clusters

The EU Taxonomy Regulation aligns primarily with *water source transparency and documentation, water-use efficiency and minimisation,* and *long-term water sustainability and cumulative impacts.* This alignment reflects the Regulation's focus on maintaining good water status, improving water management and efficiency, preventing pollution, and avoiding the deterioration of surface water, groundwater and marine waters over time. These water-related requirements are embedded within a high-level sustainability classification framework and implemented through delegated technical screening criteria, rather than through project-level water-use rules.

4.2.3.2 Regulation (EU) 2021/947–Neighbourhood, Development and International Cooperation Instrument (NDICI–Global Europe) (Regulation (EU) 2021/947, 2021)

This Regulation establishes the Neighbourhood, Development and International Cooperation Instrument–Global Europe (NDICI–GE), the European Union's primary external financing programme for development cooperation under the multiannual financial framework. It is a binding budgetary and programming instrument that governs how EU development assistance is allocated and implemented across partner countries, particularly least developed countries and countries in fragile or conflict-affected situations.

While the NDICI–GE is not sector-specific and does not target hydrogen explicitly, it is relevant for green hydrogen development outside the EU because it shapes the conditions under which EU-funded energy, infrastructure and industrial projects are supported internationally. This includes projects related to renewable energy systems, hydrogen production and associated water and resource management in partner countries.

› What it actually says about water in hydrogen production

The NDICI–GE addresses water primarily as a development and sustainability objective rather than as a technical input to hydrogen production. Water appears repeatedly across the Regulation's objectives, priority areas and annexes as a core element of human development, environmental protection and natural resource governance.

At a general level, actions supported under the NDICI–GE are expected to contribute to social inclusion and human development, explicitly including water, sanitation and hygiene. In the environmental and climate-related priorities, the NDICI–GE promotes integrated, sustainable and participatory management of water resources, including transboundary water cooperation, water resources governance, and the strengthening of institutional capacity for water management.

Meanwhile, in the context of energy and climate action, the NDICI–GE supports access to sustainable renewable energy in developing countries and stresses compliance with high environmental standards, including the assessment of environmental impacts. Water considerations are not implemented in relation to hydrogen or energy projects but are embedded through broader principles such as sustainable resource management, precaution, polluter pays, and conflict-sensitive governance of natural resources.

The Regulation also links water to monitoring and accountability through key performance indicators, including indicators on access to improved drinking water and sanitation, and on the sustainable management of freshwater ecosystems. However, it does not establish project-level requirements on water abstraction, efficiency, desalination, or competition with local water uses for specific technologies such as hydrogen.

› Implications for water-related sustainability criteria

For green hydrogen projects supported through NDICI–GE -funded instruments, the Regulation creates an enabling framework rather than direct technical or procedural water requirements. It sets expectations that EU-supported actions contribute to sustainable and integrated water management, protect water-related ecosystem services, and support access to safe water and sanitation as part of broader development objectives.

At the same time, the NDICI–GE leaves the translation of these objectives into concrete project-level water criteria to downstream implementation mechanisms, financing agreements and partner country frameworks. It does not itself define how water use for hydrogen production should be assessed, managed or limited, nor does it establish specific safeguards against water stress or competition with local water uses in energy projects.

› Indicative criteria clusters

This NDICI–GE aligns with *long-term water sustainability and cumulative impacts*, through its emphasis on integrated water resource management, ecosystem protection and sustainable development outcomes over time. It also aligns with *governance, permitting, and stakeholder participation*, given its focus on good governance, institutional capacity building, participatory approaches and the involvement of local authorities, communities and civil society in natural resource management.

It does not establish direct requirements related to *water source transparency and documentation, water-use efficiency and minimisation, avoidance of competition with drinking water and essential local uses, or environmentally responsible desalination and discharge* at the level of hydrogen or energy projects. These aspects are addressed only indirectly through broader development, environmental and governance objectives rather than through explicit sustainability criteria.

The table below summarises the documents discussed in this subsection and indicates which recurring water-related sustainability criteria they address.

Table 5.
Summary of documents and corresponding water-related sustainability criteria addressed in European Union Regulations

REGULATION NAME	CRITERIA
Regulation (EU) 2021/947	Avoidance of competition with drinking water and essential local uses
Regulation (EU) 2021/947	Environmentally responsible desalination and discharge
Regulation (EU) 2021/947	Governance, permitting, and stakeholder participation
Regulation (EU) 2020/852 (EU) 2021/947	Long-term water sustainability and cumulative impacts
Regulation (EU) 2020/852 (EU) 2021/947	Water source transparency and documentation
Regulation (EU) 2020/852 (EU) 2021/947	Water-use efficiency and minimisation

4.2.4 Document type: Voluntary Certification Standard

At the end of this subsection, a summary table provides an overview of the documents discussed and indicates which recurring water-related sustainability criteria they address, as defined in Section 3.1.

4.2.4.1 Roundtable on Sustainable Biomaterials (RSB) Standard for Advanced Fuels v2.6 (RSB–The Roundtable on Sustainable Biomaterials, 2023)

The RSB standard is a voluntary, international certification framework covering the production and trading of advanced fuels, including renewable hydrogen, renewable fuels of non-biological origin (RFNBOs) and electrofuels. It applies to operators using renewable electricity and a wide range of feedstocks, including end-of-life products and residues. For renewable hydrogen, the standard requires compliance with the overarching RSB Principles and Criteria, which aim to minimise negative environmental, social and economic impacts across the full operation. RSB is widely used in sustainability certification contexts and is relevant for hydrogen projects seeking market access or credibility beyond purely climate-based criteria.

› What it actually says about water in hydrogen production

Water is addressed in RSB through a comprehensive and explicit set of sustainability principles that apply to renewable hydrogen production via electrolysis. Operators producing renewable hydrogen are required to demonstrate compliance with the RSB Principles and Criteria (RSB–Roundtable on Sustainable Biomaterials Association, 2025), including **Principle 9 on water** and **Principle 11 on technology use and waste management**. Additionally, where desalination plants are used for water obtention, operators must comply with renewable electricity requirements and with waste management provisions under Principle 11.

Principle 9 establishes that operations shall maintain or enhance the quality and quantity of surface and groundwater resources and respect formal or customary water rights. It requires that water use shall not come at the expense of water needed by local or indigenous communities and that potential impacts on water availability and ecosystems are assessed and mitigated through the impact assessment process. Water resources under legitimate dispute shall not be used unless disputes are resolved through negotiated agreements following a Free, Prior and Informed Consent process (FPIC).

The standard further requires operators to implement a water management plan aimed at efficient water use and protection of water quality, including monitoring, public availability of the plan where possible, consistency with local and regional water management plans, and provisions for wastewater reuse or recycling. Operations shall not contribute to depletion of water resources beyond natural replenishment capacities and shall avoid withdrawals that alter the natural course or equilibrium of water bodies. Additional provisions address protection of aquifer recharge areas, prevention of pollution, treatment of wastewater and runoff, and, where applicable, reversal of prior water resource degradation attributable to the operator.

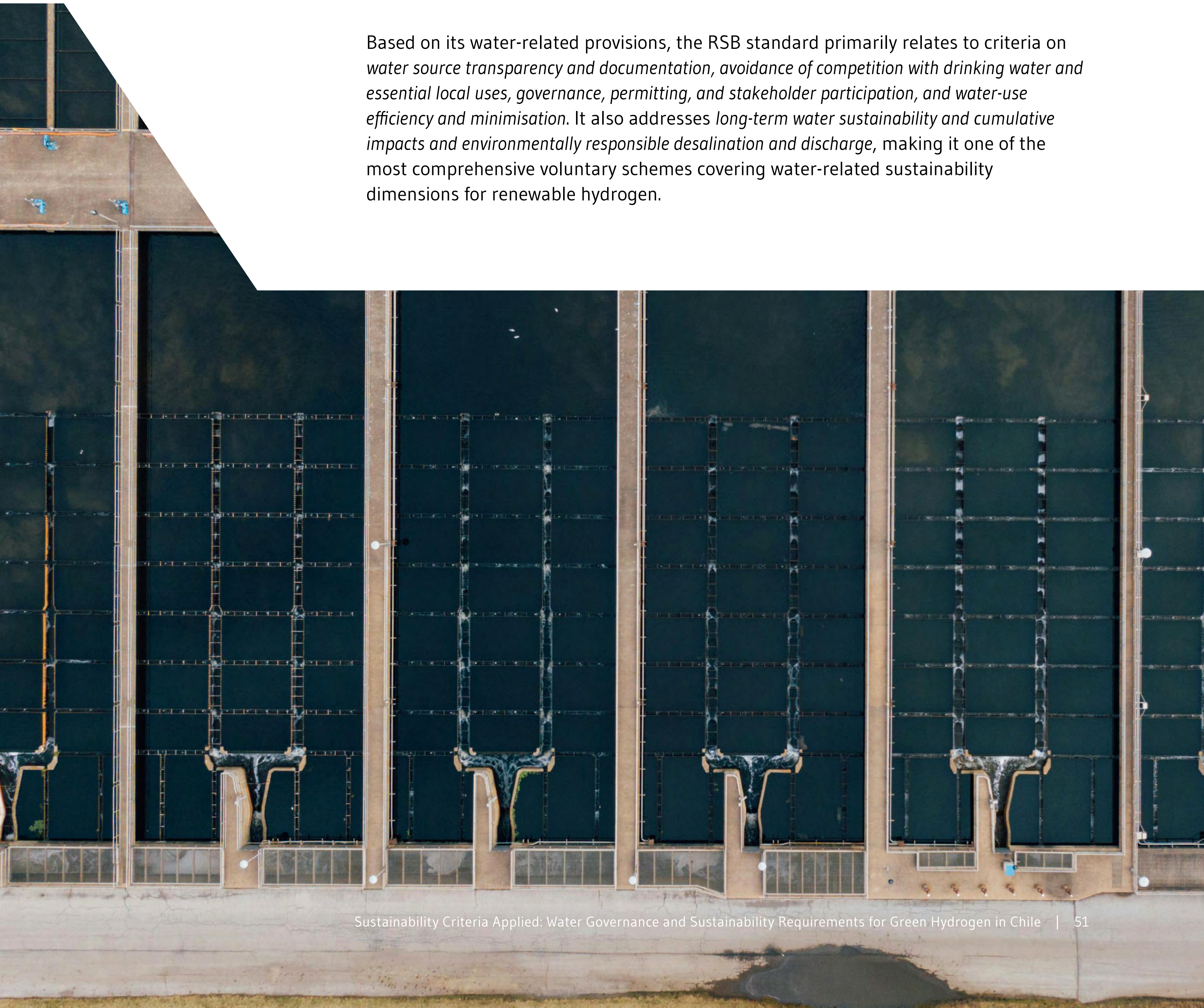
Through **Principle 11**, RSB also addresses water indirectly by requiring that technologies, residues, wastes and by-products are managed in a way that does not damage soil, water or air, including safeguards against contamination and requirements for waste and by-product management plans.

› Implications for water-related sustainability criteria

RSB represents one of the most detailed voluntary certification frameworks addressing water in renewable hydrogen production. It establishes substantive expectations covering water rights, water availability, water quality, and management practices, enforced through impact assessments, management plans and monitoring requirements. Rather than prescribing quantitative water-use thresholds, the standard relies on procedural safeguards, rights-based protections and continuous improvement obligations, making it particularly relevant for projects operating in water-sensitive or contested contexts.

› Indicative water criteria clusters

Based on its water-related provisions, the RSB standard primarily relates to criteria on *water source transparency and documentation, avoidance of competition with drinking water and essential local uses, governance, permitting, and stakeholder participation, and water-use efficiency and minimisation*. It also addresses *long-term water sustainability and cumulative impacts and environmentally responsible desalination and discharge*, making it one of the most comprehensive voluntary schemes covering water-related sustainability dimensions for renewable hydrogen.



4.2.4.2 TÜV SÜD–Standard CMS 70 (Version 07/2024) (TÜV SÜD, 2024)

CMS 70 is a voluntary certification standard for the production and marketing of hydrogen and hydrogen derivatives from renewable energies. It is based on European legislation but is applicable worldwide and defines the requirements that must be met for hydrogen to be certified as "GreenHydrogen/derivatives" under the TÜV SÜD scheme. The standard is intended to support climate mitigation objectives and to provide assurance to markets and customers, including through optional additional requirements that may respond to specific buyer expectations. Compliance with CMS 70 is separate from, and not equivalent to, RFNBO certification under RED II.

› What it actually says about water in hydrogen production

Water is explicitly recognised in CMS 70 as a critical sustainability concern, particularly in regions affected by water scarcity. The standard states that the additional use of fossil water resources and drinking water for hydrogen production in arid regions shall not have a negative impact on the population and the environment. Within the certification scope, water treatment is included as part of the production system boundary, and certificate holders are required to document water sources and water availability as part of the certification process. Where seawater desalination is used, the standard requires that desalination shall be powered by renewable energy and/or previously unused waste heat, with proof provided either within the certification or through verification under a recognised third-party standard. CMS 70 further excludes the use of water resources originating from regions with high or extremely high water stress for certified hydrogen production and introduces additional management requirements for water sourced from regions with medium to high water stress.

› Implications for water-related sustainability criteria

CMS 70 functions as one of the more explicit voluntary certification schemes addressing water in hydrogen production. It does so by combining exclusion criteria based on water stress, documentation and verification of water sources, and requirements for water efficiency management. As such, the standard establishes clear expectations on acceptable water sourcing and management for certified hydrogen, particularly relevant for projects in water-scarce regions and for buyers seeking assurance on water-related sustainability risks.

› Indicative water criteria clusters

Based on its water-related provisions, CMS 70 primarily relates to criteria on *water source transparency and documentation*, and *avoidance of competition with drinking water and essential local uses*. It also addresses *water-use efficiency and minimisation*, while *long-term water sustainability and cumulative impacts* beyond the project level are not explicitly covered.

4.2.4.3 Climate Bond Initiative (CBI)–The Hydrogen Eligibility Criteria of the Climate Bonds Standard & Certification Scheme (Climate Bond Initiative, 2023)

The Climate Bonds Standard and Certification Scheme is a voluntary, investor-orientated certification framework designed to signal the climate integrity of assets, projects and, increasingly, entities financed through labelled green or climate bonds. It is primarily a screening and assurance tool for capital markets, addressing concerns over greenwashing by establishing sector-specific eligibility criteria and overarching requirements for management of proceeds and reporting. For hydrogen, the standard applies to use-of-proceeds bonds financing hydrogen production facilities, decarbonisation measures within hydrogen facilities, and hydrogen delivery infrastructure across the supply chain.

› What it actually says about water in hydrogen production

Water considerations are addressed within the Climate Bonds hydrogen criteria primarily through adaptation and resilience requirements and through broader environmental impact provisions. Hydrogen-related investments seeking certification must comply with sector-specific eligibility criteria, including adaptation and resilience components that require identification of system boundaries and critical interdependencies. These interdependencies explicitly include relationships between hydrogen production measures and surrounding water bodies and water courses, as well as exposure to flood zones. Certified measures shall demonstrate that they do no harm to the climate resilience of the system in which they operate, including by avoiding adverse effects on local water bodies and water courses.

For hydrogen production facilities, the standard requires that an Environmental Impact Assessment (EIA) is conducted in line with local regulations and by an independent third-party expert. This assessment must include potential impacts on water. In addition, projects are required to have a water resource management plan that specifies whether freshwater aquifers are used and whether these aquifers are currently used for human consumption, alongside a water-use licence issued by the relevant environmental regulator. Projects must demonstrate, through a local water availability assessment, that water use for hydrogen production does not impact water availability for human consumption and agriculture. The standard further states that hydrogen production assets should not be located in regions with high water stress where seawater desalination is not available as an alternative. Where desalination is used for hydrogen production, the Climate Bonds hydrogen criteria require a brine management plan developed and approved within the EIA process. This plan must address potential environmental risks and mitigation measures associated with brine disposal.

› Implications for water-related sustainability criteria

Within the CBI, water-related sustainability considerations for hydrogen are primarily embedded in environmental safeguards, risk screening and project-level assessments linked to investment eligibility. The standard does not prescribe water-use limits or efficiency benchmarks but relies on EIAs, licensing requirements and location-based exclusions to address water stress and water availability risks. As such, water functions as a material environmental risk factor influencing investment eligibility rather than as a standalone sustainability performance criterion.

› Indicative water criteria clusters

Based on its provisions for hydrogen, the CBI aligns primarily with water source transparency and documentation, avoidance of competition with drinking water and essential local uses, and governance, permitting, and stakeholder participation through licensing and EIA requirements. It also relates to long-term water sustainability and cumulative impacts via adaptation and resilience screening, and to environmentally responsible desalination and discharge through mandatory brine management planning where desalination is used.

4.2.4.4 Green Hydrogen Organisation (GH2)–Green Hydrogen Standard 2023 (Green Hydrogen Organisation (GH2), 2023)

The Green Hydrogen Standard establishes a global definition of green hydrogen as hydrogen produced through water electrolysis using 100% or near-100% renewable energy with close to zero greenhouse gas emissions. Beyond this technical definition, the standard functions as a voluntary certification and accreditation framework that places strong emphasis on the environmental, social and governance consequences of green hydrogen production. It requires that both project-level impacts and broader development opportunities associated with green hydrogen are evaluated and addressed throughout the project life cycle.

› What it actually says about water in green hydrogen production

Water considerations are addressed explicitly through requirements on governance, impact assessment and project transparency, with a dedicated provision on water use and quality. GH2 accreditation and certification require that project operators demonstrate appropriate government approval and stakeholder engagement processes, including the publication of a publicly accessible summary of licences and approvals. Where applicable, this documentation shall address water rights alongside property rights, land use, environmental and public health approvals, and must be made available to independent assurance providers.

From a social perspective, the standard sets expectations that projects undergo social impact assessments or similar processes to identify potential impacts on communities, livelihoods and vulnerable groups. These assessments are expected to be conducted in line with applicable regulatory requirements and to inform ongoing community engagement. Provisions addressing affected communities, livelihoods and Indigenous Peoples require that projects protect community assets and resources and adhere to informed consultation and participation processes, including the principle of FPIC where Indigenous Peoples are concerned. While not water-specific, these provisions are directly relevant to water access, water rights and water-dependent livelihoods.

Environmental impacts, including water-related impacts, are addressed through the expectation that projects are subject to an EIA and that an environmental management plan is established for the lifetime of the project. Within this framework, **Requirement 5B** focuses specifically on water use and quality. The objective of this provision is to ensure that green hydrogen projects address water availability and sustainable water management, including risks related to water stress and, where applicable, desalination.

GH2 requires a publicly accessible evaluation of the project's usage of water and its approach to wastewater treatment and water pollution. This evaluation must describe how and where water is withdrawn, consumed and discharged, identify total water consumption with particular attention to water-stressed areas, and explain how water-related impacts are addressed, including through stakeholder engagement and stewardship of water as a shared resource. Project operators must demonstrate that they have identified and implemented technically and financially feasible measures to improve water-use efficiency, particularly where water access and water stress pose risks. Where desalination is used, project operators are required to demonstrate that desalination plans do not have a negative effect on the water source. The evaluation must also describe any minimum standards applied to effluent quality and how these standards were determined.

› Implications for water-related sustainability criteria

Within the GH2 framework, water is treated as both an environmental resource and a social governance issue. The standard relies on transparency, public disclosure, impact assessments and stakeholder engagement to address water availability, water stress and water quality risks. Water considerations are closely linked to broader expectations around community impacts, Indigenous rights and responsible project governance, positioning water as a shared and contested resource that must be managed in a socially legitimate and environmentally responsible manner.

› Indicative water criteria clusters

Based on its provisions for green hydrogen, the GH2 standard aligns strongly with *water source transparency and documentation, governance, permitting, and stakeholder participation*, and *avoidance of competition with drinking water and essential local uses* through its emphasis on public disclosure, water rights and impact assessments. It also clearly addresses *water-use efficiency and minimisation* and *environmentally responsible desalination and discharge*, while situating water within *long-term water sustainability and cumulative impacts* through life-cycle environmental and social management expectations.

4.2.4.5 International Finance Corporation (IFC)–Performance Standards on Environmental and Social Sustainability (IFC, 2012)

The IFC Performance Standards form part of the IFC Sustainability Framework and constitute a mandatory set of environmental and social requirements for projects financed by the IFC, including project and corporate finance provided directly or through financial intermediaries. The Performance Standards are directed at clients and provide guidance on how to identify, assess and manage environmental and social risks and impacts throughout the life of an investment. While originally developed for IFC-financed projects, they are widely applied by other international financial institutions and lenders as a global benchmark for environmental and social risk management.

The framework consists of eight Performance Standards that apply across the project life cycle, with Performance Standard 1 establishing the overarching requirement for environmental and social risk assessment and management. Water is addressed as a cross-cutting issue across multiple standards, rather than through a single standalone water instrument.

› What it actually says about water in hydrogen production

Water-related considerations are embedded primarily within Performance Standard 1 on Assessment and Management of Environmental and Social Risks and Impacts and Performance Standard 3 on Resource Efficiency and Pollution Prevention, with additional relevance in standards addressing community impacts, land use, biodiversity and Indigenous Peoples.

Performance Standard 1 applies to all projects with environmental and social risks and requires clients to establish and maintain an Environmental and Social Management System (ESMS). The ESMS is expected to be a continuous, adaptive process that identifies and evaluates environmental and social risks, applies a mitigation hierarchy, and ensures stakeholder engagement and information disclosure. Water-related risks and impacts are explicitly included within the scope of environmental and social risk identification and assessment, particularly where they affect local communities or ecosystems.

Performance Standard 3 focuses explicitly on resource efficiency and pollution prevention. It recognises that increased economic activity can place pressure on finite resources, including water, and establishes objectives to promote more sustainable resource use and to avoid or minimise adverse impacts on human health and the environment. Where a project is a potentially significant consumer of water, clients are required to adopt measures to avoid or reduce water usage so that water consumption does not have significant adverse impacts on others. The standard specifies that such measures may include technically feasible water conservation measures, the use of alternative water supplies, water consumption offsets to reduce total demand within available supply, and the evaluation of alternative project locations.

In parallel, Performance Standard 3 requires clients to avoid the release of pollutants to air, water and land, or to minimise and control such releases where avoidance is not feasible. This obligation applies to routine, non-routine and accidental pollution and includes responsibility for addressing historical water or groundwater contamination where the client is legally responsible, in accordance with national law or Good International Industry Practice.

Other Performance Standards indirectly reinforce water-related protections. **Performance Standard 4** addresses community health and safety, which may include risks associated with water pollution or scarcity. **Performance Standard 5** on land acquisition and involuntary resettlement and **Performance Standard 7** on Indigenous Peoples are relevant where water access, water rights or water-dependent livelihoods are affected. **Performance Standard 6** addresses biodiversity conservation and sustainable management of natural resources, including aquatic ecosystems.

› Implications for water-related sustainability criteria

Within the IFC framework, water is treated as a critical environmental and social risk factor that must be identified, assessed and managed through project-specific processes. The emphasis lies on avoidance and minimisation of harm, protection of affected communities, efficient resource use and pollution prevention, supported by continuous monitoring, stakeholder engagement and adaptive management. Water scarcity, competing uses and cumulative impacts are expected to be addressed through the ESMS and associated assessments, particularly for projects with high water demand or pollution potential.

› Indicative water criteria clusters

The IFC Performance Standards align strongly with *governance, permitting, and stakeholder participation* through their ESMS and stakeholder engagement requirements, and with *long-term water sustainability and cumulative impacts* via life-cycle risk management and continuous improvement. They explicitly address *water-use efficiency and minimisation* and *water source transparency and documentation* in cases of significant water consumption. Protections related to *avoidance of competition with drinking water and essential local uses* are implied through impact assessment and community safeguards, while *environmentally responsible desalination and discharge* are directly addressed under Performance Standard 3.

The table below summarises the documents discussed in this subsection and indicates which recurring water-related sustainability criteria they address.

Table 6.
Summary of documents and corresponding water-related sustainability criteria addressed in Voluntary Certification Standard

DOCUMENT NAME	CRITERIA
TÜV SÜD CMS 70, GH2, CBI, RSB , IFC	Avoidance of competition with drinking water and essential local uses
GH2, CBI, RSB , IFC	Environmentally responsible desalination and discharge
GH2, CBI, RSB , IFC	Governance, permitting, and stakeholder participation
GH2, CBI, RSB , IFC	Long-term water sustainability and cumulative impacts
TÜV SÜD CMS 70, GH2, CBI, RSB , IFC	Water source transparency and documentation
TÜV SÜD CMS 70, GH2, RSB , IFC	Water-use efficiency and minimisation

4.2.5 Document type: Research and Policy-oriented Literature

At the end of this subsection, a summary table provides an overview of the documents discussed and indicates which recurring water-related sustainability criteria they address, as defined in Section 3.1.

4.2.5.1 Germany's Power-to-X policy for climate-neutral transport (Torkayesh and Venghaus, 2024)

The authors present a scientific policy analysis of Germany's and the EU's policy landscape for PtX fuels in climate-neutral transport. They review how policy documents discuss PtX fuels and the resources required for their production, and use content analysis to identify gaps in policy integration. This analysis is relevant for hydrogen and PtX because it explicitly examines whether the policy framework addresses key production inputs, including water, and whether the regulatory landscape provides targeted support for managing resource constraints and sustainability risks.

› What it actually says about water in hydrogen production

The authors identify water as a necessary input for PtX fuels and hydrogen production, but argue that water is weakly integrated in the policy landscape compared to other resources. In their analysis of policy documents, renewable electricity (solar and wind) and carbon use are extensively addressed, whereas water systems emerge as one of the least discussed resources in a cohesive manner alongside PtX policies. The authors describe this as a significant oversight, given that effective water management is essential for sustainable PtX production.

The paper further states that although water is highlighted in most identified policies as a key element, no policy specifically regulates water use for hydrogen production within the context of renewable fuels. In contrast, hydrogen, and especially green hydrogen, is discussed in most identified policies and is regulated through multiple policies covering technical, economic, social, environmental and political dimensions.

In their discussion of challenges and implications, the paper links water to a broader "water-energy-carbon nexus" and argues that water use requires more targeted regulatory support to manage demand in large-scale plants. It also states that ensuring sustainable water use is important to prevent conflicts over water resources, particularly where water scarcity may become an issue as hydrogen demand grows. In its policy implications, it points to the Water Framework Directive as a policy regulating water sources and summarises its general objectives, and suggests that updating relevant policies or introducing a specified policy on water use for hydrogen production could help optimise water use pathways and prevent conflicts with other sectors.

› Implications for water-related sustainability criteria

Within the framing of this paper, the main implication is not that water criteria already exist, but that they are insufficiently developed or insufficiently connected to hydrogen and PtX policy. The authors present a clear gap: water is acknowledged as important, yet there is no policy specifically regulating water use for hydrogen production in the renewable fuels context. They imply that future sustainability criteria and regulatory approaches would need to treat water as an integrated part of PtX governance, rather than a peripheral consideration. The paper also implies that sustainability assurance systems (including certification) are becoming relevant as hydrogen demand increases, and that principles such as simplicity and transparency are important for credibility.

› Indicative water criteria clusters

This paper aligns most clearly with *long-term water sustainability and cumulative impacts*, because it emphasises future demand growth, resource volatility, and the need for a robust framework to manage the water-energy-carbon nexus over time. It also aligns with *governance, permitting, and stakeholder participation*, insofar as it argues for more targeted regulatory support and identifies the absence of specified legislation on water systems for hydrogen production.

In contrast, the paper does not set out concrete requirements fo*r water source transparency and documentation, water-use efficiency and minimisation, avoidance of competition with drinking water and essential local uses, or environmentally responsible desalination and discharge*. Where it refers to conflict risks, it does so as a general concern linked to scarcity and growing demand, not as defined criteria.

4.2.5.2 Sustainability regulations for PtX projects: Scope and impact analysis (Bube et al., 2025)

This paper is an analytical research article examining the scope, content and practical implications of existing sustainability regulations, standards and support schemes relevant to PtX projects. Rather than proposing a new regulatory framework, it assesses how current legal instruments, certification schemes and incentive mechanisms address environmental and social sustainability aspects, with a particular focus on potential gaps and trade-offs. The analysis is relevant for green hydrogen because PtX projects depend on hydrogen production at scale and are therefore directly affected by how water, land, emissions and social impacts are regulated across jurisdictions.

› What it actually says about water in hydrogen production

The authors identify water as an inherent input for hydrogen production, both as a feedstock for electrolysis and for auxiliary purposes such as cooling, heating and cleaning. From a techno-economic perspective, they conclude that providing a sustainable water supply generally does not constitute a major cost or energy burden for PtX projects. On this basis, they argue that extending sustainability requirements to explicitly include water use would, in most cases, not pose a significant technical or economic barrier.

At the same time, the paper observes that existing mandatory sustainability regulations for PtX projects tend to prioritise greenhouse gas emissions and energy sources, while other environmental aspects, including water sources, water use and waste management, are often insufficiently addressed. Where environmental impacts beyond climate are considered, this typically occurs through environmental impact assessments, which may include water-related aspects indirectly. The authors highlight that water, land use and broader environmental impacts are particularly contentious in large-scale projects, where cumulative effects and local pressures can become significant.

› Implications for water-related sustainability criteria

The analysis suggests that current PtX-related regulatory frameworks do not systematically translate the acknowledged importance of water into explicit, harmonised sustainability criteria. While water use is recognised as necessary and manageable from a technical standpoint, regulatory attention remains fragmented and often indirect, relying on general environmental assessment procedures rather than dedicated water-related requirements for hydrogen production. The authors argue that incorporating clearer environmental and social criteria, including water-related considerations, could support more holistic sustainability outcomes, but also acknowledge that doing so would increase regulatory complexity and project development effort. They therefore note a tension between expanding sustainability requirements and maintaining feasibility and competitiveness of PtX projects.

› Indicative water criteria clusters

The paper aligns most clearly with *long-term water sustainability and cumulative impacts*, through its emphasis on large-scale projects and the potential for cumulative environmental pressures, and with *governance, permitting, and stakeholder participation*, insofar as water and other environmental impacts are primarily addressed through environmental impact assessments and broader regulatory processes. The paper does not point to consistent requirements related to *water source transparency and documentation, water-use efficiency and minimisation, avoidance of competition with drinking water and essential local uses, or environmentally responsible desalination and discharge*, noting instead that these aspects are often weakly specified or absent in existing PtX sustainability frameworks.

4.2.5.3 Green hydrogen production: Integrating environmental and social criteria to ensure sustainability (Blohm and Dettner, 2023)

This paper examines how environmental and social criteria can be integrated into green hydrogen production to ensure sustainability. It focuses on identifying key resource-related constraints and trade-offs, rather than proposing a binding regulatory framework. The paper is relevant for green hydrogen policy because it explicitly addresses water availability, water stress and desalination as sustainability considerations that may constrain where and how hydrogen production can occur.

› What it actually says about water in hydrogen production

The authors identify freshwater as a necessary input for electrolysis and explicitly frame freshwater availability as a limiting factor for sustainable green hydrogen production in many regions. They argue that surface and groundwater should only be used for electrolysis in areas where sufficient freshwater is available for human consumption and agriculture, and where additional withdrawals do not cause water stress. A water availability threshold of less than 1,700 m3 per person per year is cited as a general guideline beyond which further regional water demand analysis is considered necessary, with reference to SDG 6 as an initial orientation for national-level water availability and withdrawal rates.

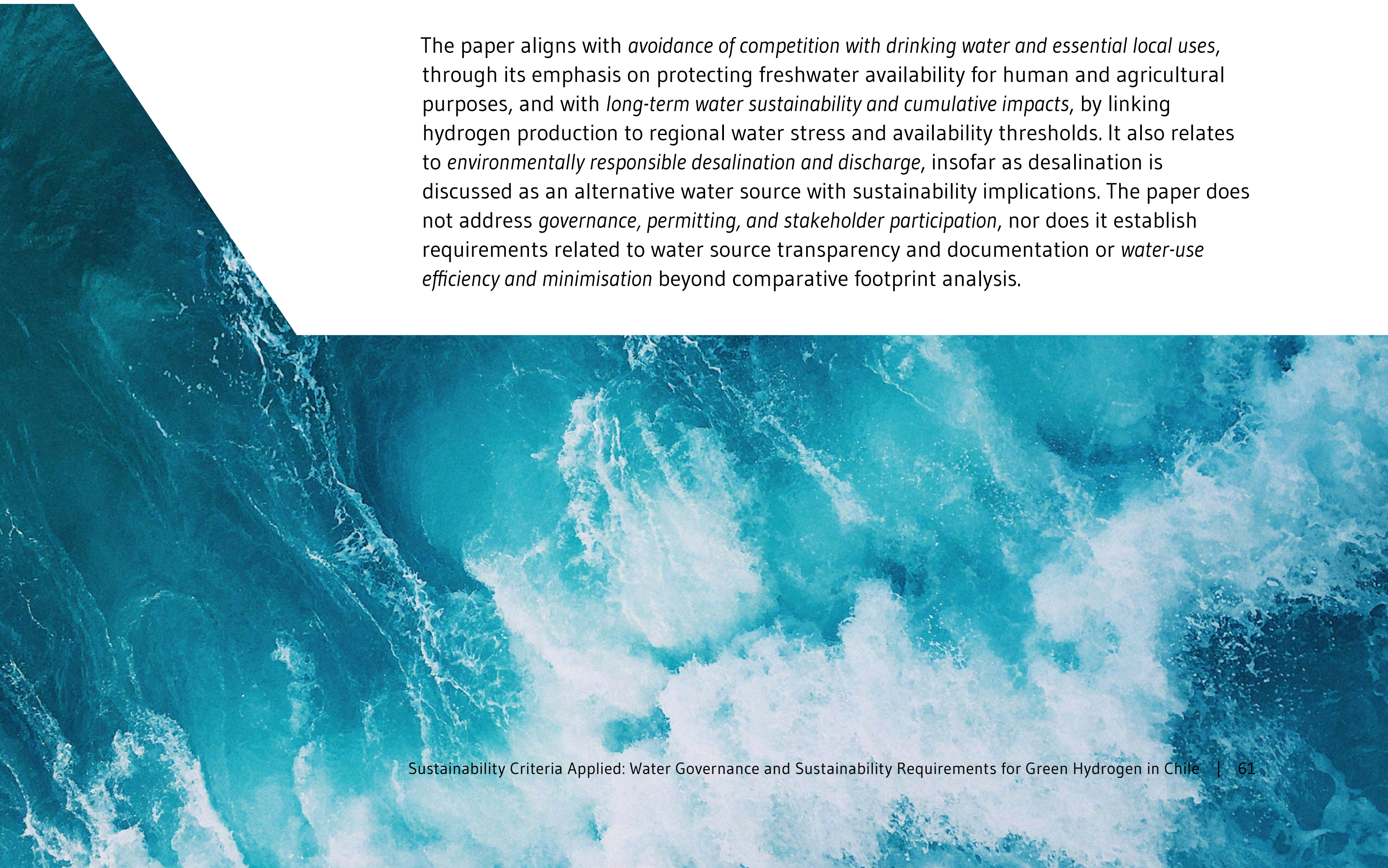
The paper further discusses the water footprint of electrolytic hydrogen, noting that it is strongly influenced by the electricity source used for hydrogen production. Quantitative comparisons are provided to illustrate differences in water footprint associated with wind, solar and nuclear energy, including both operational and construction-related water use. In regions where desalination is already required to supply water to the population, the authors argue that additional desalination capacity would be necessary for hydrogen production. They note that, under current reverse osmosis assumptions, the additional energy demand associated with desalinated water for electrolysis is relatively small compared to freshwater-based production. The paper also highlights that direct use of saline or brackish water could improve sustainability, but is not yet technically mature.

› Implications for water-related sustainability criteria

The analysis implies that water-related sustainability criteria for green hydrogen should explicitly account for regional water availability and existing water stress, rather than treating water as an unconstrained input. The authors' use of quantitative thresholds and references to Sustainable Development Goal 6 "Goals 6: *Ensure availability and sustainable management of water and sanitation for all*" (SDG 6) suggest a need for context-specific water assessments prior to project development. At the same time, the discussion of desalination indicates that alternative water sources can reduce pressure on freshwater systems, provided that additional infrastructure and energy requirements are taken into account. The paper does not propose governance mechanisms or regulatory instruments, but frames water constraints as a substantive sustainability condition for hydrogen production.

› Indicative water criteria clusters

The paper aligns with *avoidance of competition with drinking water and essential local uses*, through its emphasis on protecting freshwater availability for human and agricultural purposes, and with *long-term water sustainability and cumulative impacts*, by linking hydrogen production to regional water stress and availability thresholds. It also relates to *environmentally responsible desalination and discharge*, insofar as desalination is discussed as an alternative water source with sustainability implications. The paper does not address *governance, permitting, and stakeholder participation*, nor does it establish requirements related to water source transparency and documentation or *water-use efficiency and minimisation* beyond comparative footprint analysis.



4.2.5.4 PtX.Sustainability Dimensions and Concerns (PtX Hub, 2022)

This report is an analytical and position-oriented assessment of sustainability dimensions associated with PtX and green hydrogen production. It does not establish binding requirements but aims to identify environmental, social and systemic concerns that may arise as PtX deployment scales globally. The report is relevant for green hydrogen policy because it provides a structured discussion of water stress, water footprint and desalination as central sustainability considerations, particularly in regions with high renewable energy potential.

› What it actually says about water in hydrogen production

The report frames water as a foundational input for green hydrogen and PtX production, alongside renewable electricity, and emphasises that analyses of water stress and water resource needs are essential components of any PtX sustainability assessment. It explicitly highlights the risk of water conflicts in regions with high renewable potential that already experience water scarcity, including North Africa, the Gulf region, Australia, Chile and parts of Southern Europe. The report stresses that competition between PtX production and drinking water demand must be avoided and that potential trade-offs and negative impacts require careful assessment. It cites evidence indicating that a large share of planned electrolyser projects is expected to be located in water-stressed regions.

At the same time, the report contextualises these concerns by comparing aggregate water demand for future PtX production with current global water use. It argues that, at a global scale, projected water requirements for green hydrogen remain small relative to current municipal, industrial and agricultural water consumption, and lower than water demand associated with several alternative fuel pathways, including biofuels and fossil-based power generation. On this basis, the report suggests that a shift towards renewable power and green hydrogen could, in principle, contribute to easing water stress, provided that water sourcing is managed appropriately.

The report further states that desalination is likely to play a central role in supplying water for PtX production in arid regions, with a large share of planned projects expected to rely on desalinated water. While the additional energy and cost implications of desalination are described as relatively limited, the report highlights significant environmental concerns related to brine disposal. It notes that brine discharge can negatively affect aquatic ecosystems through increased salinity, temperature and pollutant concentrations, and that long-term impacts remain insufficiently studied. The report therefore calls for ecological assessments based on local indicators and for policy measures addressing brine treatment, disposal location and potential reuse of minerals and chemicals.

› Implications for water-related sustainability criteria

The report implies that sustainability criteria for green hydrogen should be region-specific and grounded in assessments of local water stress rather than relying on global averages. It suggests that avoiding conflicts with drinking water supply is a central condition for socially acceptable PtX deployment, particularly in arid and water-stressed regions. At the same time, the report cautions against overestimating global water scarcity impacts without considering comparative water footprints across energy pathways. Its discussion of desalination highlights that alternative water sources can mitigate freshwater competition but introduce new environmental risks that require regulatory attention. The report does not define formal governance mechanisms but argues that independent assessments and policy obligations are necessary to address cumulative and long-term impacts, especially for desalination-related discharges.

› Indicative water criteria clusters

The PtX Hub analysis aligns with *avoidance of competition with drinking water and essential local uses*, through its explicit emphasis on preventing conflicts between PtX production and human water demand. It also aligns with long-term water sustainability and cumulative impacts, given its focus on water stress, future climate impacts and large-scale deployment effects. *Environmentally responsible desalination and discharge* is directly addressed through the discussion of desalination dependency, brine disposal and ecological impacts. The report does not establish concrete requirements related to *governance, permitting, and stakeholder participation*, nor does it define expectations for *water source transparency and documentation or water-use efficiency and minimisation*, although comparative water footprint data are used for contextual analysis.

4.2.5.5 Sustainability criteria for import projects for renewable hydrogen and PtX products (The German National Hydrogen Council, 2021)

This is a position paper issued by the German National Hydrogen Council, outlining sustainability considerations for renewable hydrogen and PtX import projects, particularly in partner countries in the Global South. It is not a binding regulatory instrument, but it is policy-relevant because it articulates expectations that may inform German public funding decisions, international cooperation frameworks and political guidance for hydrogen imports. The paper explicitly links hydrogen production to development objectives and frames sustainability as a condition for international hydrogen partnerships.

› What it actually says about water in hydrogen production

The paper identifies water availability as a central risk for hydrogen production based on electrolysis, particularly in regions where freshwater resources are already scarce and may become further constrained by climate change. It explicitly warns that hydrogen production could exacerbate conflicts over water allocation if water shortages are not adequately addressed. Water use is therefore framed as both an environmental and a social issue with potential development implications.

Desalination is presented as the preferred solution where freshwater scarcity exists, but the paper explicitly acknowledges that desalination generates significant residues in the form of brine. It stresses the need to develop environmentally sound concepts for managing these residues at an early stage. The paper also refers to longer-term technological options, such as electrolysers capable of handling seawater, as an area for future research and development, while implicitly recognising that such technologies are not yet standard practice.

In its criteria for hydrogen projects, the paper states that conflicts over water allocation must be avoided and that water supply for the local population must not be endangered. Where desalination plants are developed to supply hydrogen production, the paper explicitly requires that local water supply should improve as a result, including by making part of the desalinated water available to the local population if needed. It further states that investors should require proof of such arrangements before issuing funding and that sustainable solutions must be in place for managing desalination residues.

› Implications for water-related sustainability criteria

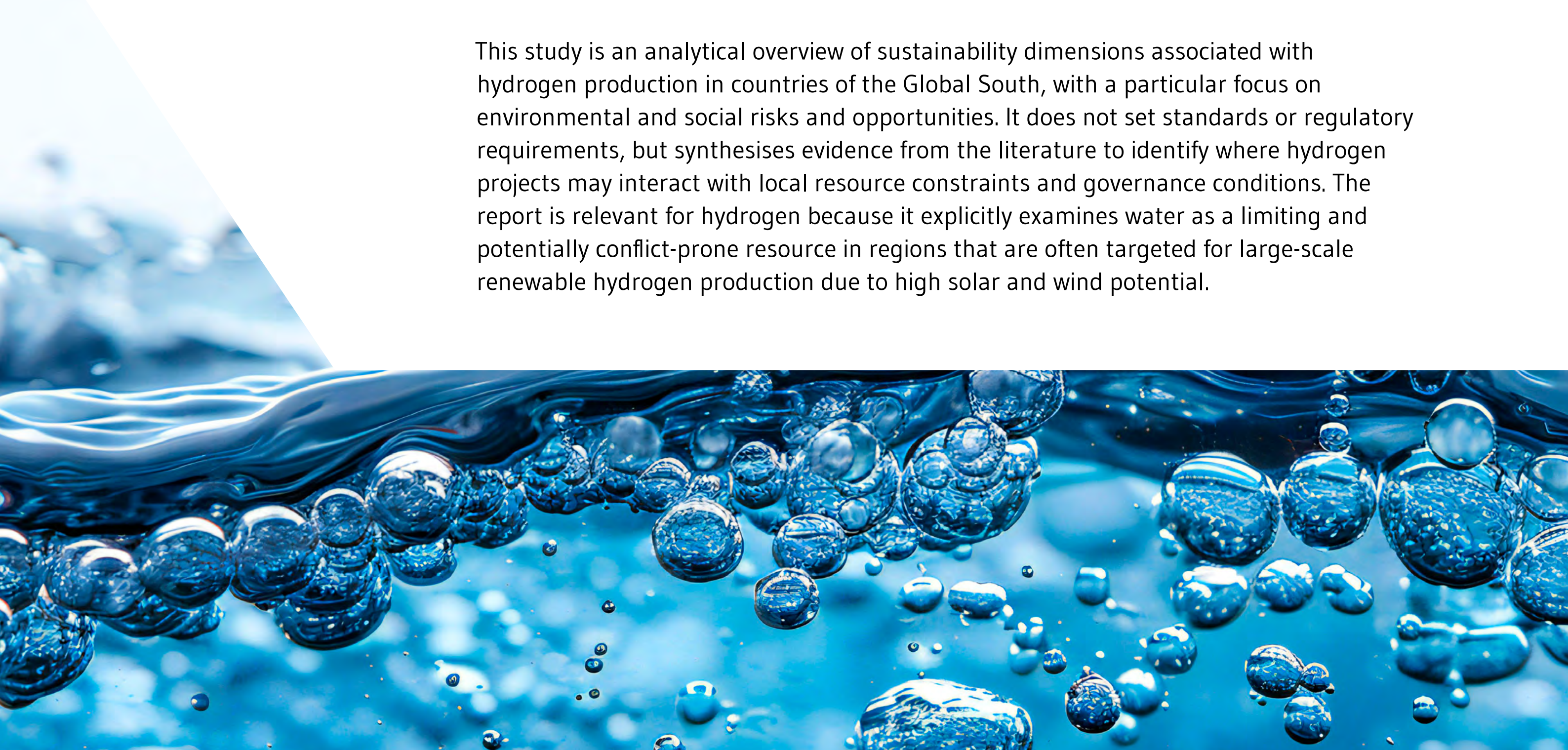
The position paper implies that water-related sustainability criteria for hydrogen import projects should prioritise the protection of local water supply and explicitly avoid competition with drinking water uses. It introduces an expectation that desalination, where used, should deliver co-benefits for local communities rather than solely serving industrial hydrogen production. It also implies a need for prior proof and conditionality in investment decisions, although it does not define formal verification procedures or institutional responsibilities. Environmental risks associated with desalination residues are acknowledged as requiring proactive management, but detailed technical standards are not specified.

› Indicative water criteria clusters

This position paper aligns with *avoidance of competition with drinking water and essential local uses*, through its explicit prioritisation of local water supply over hydrogen production. It also aligns with *environmentally responsible desalination and discharge*, given its emphasis on sustainable desalination plants, residue management and potential co-benefits for local populations. Elements of *governance, permitting, and stakeholder participation* are indirectly implied through the role assigned to investors and development cooperation, but are not explicitly developed. The paper does not address *water source transparency and documentation* or *water-use efficiency and minimisation* in a systematic manner, nor does it explicitly engage with *long-term water sustainability and cumulative impacts* beyond the immediate risk of water shortages.

4.2.5.6 Sustainability dimensions of hydrogen production in countries of the Global South (Krieger et al., 2024)

This study is an analytical overview of sustainability dimensions associated with hydrogen production in countries of the Global South, with a particular focus on environmental and social risks and opportunities. It does not set standards or regulatory requirements, but synthesises evidence from the literature to identify where hydrogen projects may interact with local resource constraints and governance conditions. The report is relevant for hydrogen because it explicitly examines water as a limiting and potentially conflict-prone resource in regions that are often targeted for large-scale renewable hydrogen production due to high solar and wind potential.



› What it actually says about water in hydrogen production

The report identifies water as one of the two essential inputs to electrolysis and highlights that hydrogen production may rely on groundwater, surface water, desalinated seawater or existing freshwater networks. It emphasises that total water demand depends not only on electrolysis itself but also on the renewable electricity technology used, particularly where water is required for cleaning photovoltaic panels or cooling concentrated solar power systems. Although overall water demand for hydrogen production is described as relatively low compared to agriculture or other sectors at national scale, the report stresses that even small additional water withdrawals can have significant local impacts in water-scarce regions.

Water-related risks are described as particularly acute in arid and semi-arid regions of the Global South, where baseline water availability is limited and water supply systems are often inadequate or unreliable. The report underlines that additional water use for hydrogen production may affect both water quantity and affordability for local populations, especially in rural areas where livelihoods depend directly on access to water for agriculture. Potential negative effects identified include competition over local water resources, degradation of drinking water quality, rising water prices, infringement of existing water rights and ecological harm from brine disposal where seawater desalination is used. Positive effects are considered possible only where deliberate measures are taken, such as investments in water infrastructure or the provision of additional freshwater to local communities through desalination plants.

The report further notes that desalination is likely to be required for many hydrogen projects in arid regions, but highlights the environmental risks associated with brine discharge, including impacts on marine ecosystems. It points to the lack of long-term evidence on cumulative ecological effects and stresses the need for careful assessment and management of desalination impacts.

› Implications for water-related sustainability criteria

Rather than proposing binding rules, the report compiles indicators, assessment tools and governance mechanisms already discussed in the literature. These include the use of baseline water stress indicators, water footprint and water scarcity footprint metrics, and ex-ante environmental impact assessments to identify local hydrological risks. It highlights the importance of excluding certain water sources in arid regions, avoiding the use of drinking water or fossil water bodies, and ensuring that desalination capacity is additional to existing supply in order to prevent competition or price distortions.

The report also points to procedural expectations such as stakeholder consultation, respect for water rights including FPIC where applicable, public reporting on water use and impacts, and the integration of water considerations into environmental management systems. For desalination, it stresses the need for efficiency standards, brine management requirements and transparent reporting across the production chain. Overall, the report frames water governance as a combination of quantitative thresholds, exclusion criteria, impact assessments and participatory processes, without prescribing a single uniform model.

› Indicative water criteria clusters

The study aligns clearly with *water source transparency and documentation, water-use efficiency and minimisation, avoidance of competition with drinking water and essential local uses, governance, permitting, and stakeholder participation, long-term water sustainability and cumulative impacts, and environmentally responsible desalination and discharge.* The report addresses all six clusters in an integrated manner, primarily by identifying risks, indicators and governance approaches discussed in the existing literature rather than by establishing new requirements.

The table below summarises the documents discussed in this subsection and indicates which recurring water-related sustainability criteria they address.

Table 7.
Summary of documents and corresponding water-related sustainability criteria addressed in Research and Policy-oriented Literature

DOCUMENT NAME	CRITERIA
Blohm & Dettner, 2023 PtX Hub, 2022 The German National Hydrogen Council, 2021 Krieger et al., 2024	Avoidance of competition with drinking water and essential local uses
Blohm & Dettner, 2023 PtX Hub, 2022 The German National Hydrogen Council, 2021 Krieger et al., 2024	Environmentally responsible desalination and discharge
Torkayesh & Venghaus, 2024 Bube et al., 2025 The German National Hydrogen Council, 2021 Krieger et al., 2024	Governance, permitting, and stakeholder participation
Torkayesh & Venghaus, 2024 Bube et al., 2025 Blohm & Dettner, 2023 PtX Hub, 2022 Krieger et al., 2024	Long-term water sustainability and cumulative impacts
Krieger et al., 2024	Water source transparency and documentation
Krieger et al., 2024	Water-use efficiency and minimisation

4.3 Water-Related Sustainability in the EU and International Framework: Key Findings

The following summary examines how recurring water-related sustainability criteria are reflected across different types of European and international documents, moving from policy-oriented instruments to regulatory frameworks, voluntary certification standards, and research and policy-oriented literature.

In the case of European Union Communications, water-related sustainability considerations are addressed in a selective and high-level manner. The document reviewed focuses primarily on *water source transparency and documentation, avoidance of competition with drinking water and essential local uses, and governance, permitting, and stakeholder participation*, reflecting an emphasis on strategic orientation, risk awareness, and alignment with broader sustainability objectives. *Long-term water sustainability and cumulative impacts* are also referenced, although they remain framed in general terms rather than through operational or enforceable requirements. The limited attention to *environmentally responsible desalination and discharge* may reflect the fact that most planned green hydrogen projects within the EU are not expected to rely on desalination as a primary water source. This is likely linked to the geographical distribution of projected projects and the lower relevance of seawater abstraction in many Member States. A similar logic may help explain why *water-use efficiency and minimisation* receive limited attention, as acute water scarcity concerns are concentrated in specific regions, notably parts of the Mediterranean, rather than across the Union as a whole ("Desalination–EU Blue Economy Observatory–European Commission," n.d.).

In the case of European Union Directives, water-related sustainability considerations are addressed in a more formalised but not uniform manner. Directive (EU) 2024/1760 (CSDDD) explicitly covers the full range of *water-related criteria, including water source transparency and documentation, water-use efficiency and minimisation, avoidance of competition with drinking water and essential local uses, and environmentally responsible desalination and discharge*. By contrast, overlap across Directives is more limited, with only *governance, permitting, and stakeholder participation and long-term water sustainability and cumulative impacts* being consistently addressed across the reviewed instruments. Directive (EU) 2024/1619 (CRD), which is focused on credit institutions, approaches water-related risks indirectly by requiring the identification, management, and monitoring of ESG risks. In practice, this may imply reliance on established voluntary frameworks, such as the IFC Performance Standards (Subsection 4.2.4.5) or comparable certification schemes, to implement ESG assessments, rather than prescribing water-specific sustainability criteria within the Directive itself.

In the case of European Union Regulations, water-related sustainability considerations are addressed with a higher degree of operational specificity, but coverage remains uneven across instruments. The two Regulations explicitly address *long-term water sustainability and cumulative impacts, water source transparency and documentation, and water-use efficiency and minimisation*, indicating a shared focus on long-term resource availability and efficiency-related aspects. Other criteria, including *avoidance of competition with drinking water and essential local uses, environmentally responsible desalination and discharge, and governance, permitting, and stakeholder participation*, are addressed only in Regulation (EU) 2021/947. This difference in emphasis may be linked to the intended scope and geographical orientation of the instruments. Regulation (EU) 2020/852 (EU Taxonomy) can be interpreted as primarily addressing activities and projects within the

European Union, where water governance frameworks are generally well established, with the notable exception of desalination. By contrast, Regulation (EU) 2021/947 (NDICI–Global Europe) targets cooperation and investment in non-EU countries, where water regulatory frameworks may be less developed or applied less consistently, increasing the relevance of criteria related to local water competition, governance, and environmental safeguards. The absence of a dedicated Directive or Regulation specifically governing desalination does not imply that desalination is excluded from the EU sustainability framework. Within the EU Taxonomy[15], desalination is recognised under climate adaptation activities, primarily in relation to augmenting drinking water supply rather than industrial water use. This framing may help explain why desalination-related considerations appear only selectively within binding regulatory instruments for green hydrogen.

Water-related sustainability is broadly recognised across different instruments and document types. Differences in emphasis reflect variations in scope, geographical focus, and intended application rather than a systematic omission of specific criteria.

In the case of voluntary certification standards, most certification schemes explicitly address *avoidance of competition with drinking water and essential local uses, governance, permitting, and stakeholder participation,* and *long-term water sustainability and cumulative impacts*, reflecting a shared focus on safeguarding local water access and managing water-related risks over the project lifetime. *Water source transparency and documentation and water-use efficiency and minimisation* are also commonly included, though not uniformly across all schemes. In contrast, *environmentally responsible desalination and discharge* is addressed by a smaller subset of certification standards, indicating a more selective treatment of desalination-specific environmental impacts within voluntary schemes. Where water is explicitly considered within certification standards, the focus is often linked to biomass production as part of the carbon input for hydrogen or fuel synthesis, rather than to water use for electrolysis itself. This can be observed, for example, in standards such as ISCC EU[16], where water-related requirements are primarily associated with biomass cultivation, or in CMS 70 (Subsection 4.2.4.2), where desalination is addressed mainly through requirements on the use of renewable energy to power water production. This suggest a potential mismatch between the scope of some certification schemes and the water-related sustainability challenges of green hydrogen production. While water use for biomass production is relevant, particularly for pathways relying on biogenic carbon, the water required as a direct input for electrolysis is not always addressed with the same level of specificity. As a result, certification approaches that focus predominantly on biomass-related water use may overlook a central water dependency of green hydrogen value chains.

In the case of research and policy-orientated literature, water-related sustainability considerations are unevenly addressed across the reviewed documents. Criteria related to *avoiding competition with drinking water and essential local use*s and *environmentally responsible desalination and discharge* are most frequently covered, appearing across several reports and position papers. *Governance, permitting, and stakeholder participation as well as long-term water sustainability and cumulative impacts* are addressed by a smaller but overlapping subset of documents. In contrast, *water source transparency and documentation and water-use efficiency and minimisation* are explicitly addressed in only one document, indicating a more limited and less consistent treatment of these criteria within the reviewed literature. This uneven coverage may reflect the predominantly European context in which much of the literature is situated, where water scarcity and competition for water resources are not uniformly perceived as pressing concerns, with notable

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[15] ("Desalination–EU Taxonomy Navigator," n. d.)

[16] (ISCC System GmbH, 2021)

regional exceptions such as parts of the Mediterranean. As a result, discussions often focus more strongly on issues such as water use for biomass production, land-use change, or environmental protection, rather than on water as a direct input to green hydrogen production. The relevance of water as a direct production input becomes more visible in literature that explicitly considers producer regions outside the European Union. Notably, only one of the reviewed studies adopts a global perspective that systematically addresses all six water-related criteria, reflecting the more acute water governance, availability, and infrastructure challenges faced in several potential green hydrogen exporting regions.

Viewed across all analysed documents, *long-term water sustainability and cumulative impacts* emerge as the most consistently addressed criterion, followed closely by *water source transparency and documentation* and the *avoidance of competition with drinking water and essential local uses*. Criteria related to *environmentally responsible desalination and discharge, water-use efficiency and minimisation*, and *governance, permitting, and stakeholder participation* are also widely referenced, though slightly less consistently across the documents. Overall, the relatively narrow range in coverage suggests that water-related sustainability is broadly recognised across different instruments and document types. Differences in emphasis reflect variations in scope, geographical focus, and intended application rather than a systematic omission of specific criteria.

> Long-term water sustainability and cumulative impacts emerge as the most consistently addressed criterion, followed closely by water source transparency and documentation and the avoidance of competition with drinking water and essential local uses.

5 ALIGNMENT ANALYSIS: WATER-RELATED SUSTAINABILITY CRITERIA IN CHILE

Building on the identification of recurring water-related sustainability criteria in the EU and international frameworks (Section 4) and the assessment of Chile's water governance and desalination context (Section 3), this section examines how these two dimensions intersect. The objective is to evaluate the degree of alignment between emerging international sustainability expectations and Chile's current regulatory practice, institutional arrangements, and infrastructure conditions relevant to green hydrogen development.

The relevance of this comparison lies in understanding whether Chile's existing governance framework is structurally equipped to meet sustainability expectations that are increasingly embedded in international hydrogen markets.

Table 8 provides a structured overview of this alignment. For each criterion, the table contrasts EU and international sustainability expectations with the current Chilean context and provides a preliminary qualitative indication of alignment. The analysis is indicative rather than exhaustive and is intended to highlight areas of alignment, emerging gaps, and potential challenges as green hydrogen production scales up. The qualitative alignment categories reflect the degree of substantive correspondence between international sustainability expectations and current Chilean practice. "Partially aligned" indicates that key elements of a criterion are formally embedded in regulation or practice, albeit incompletely. "Weak alignment" indicates limited or indirect correspondence, where the criterion is not systematically addressed or remains largely implicit.

> The objective is to evaluate the degree of alignment between emerging international sustainability expectations and Chile's current regulatory practice, institutional arrangements, and infrastructure conditions relevant to green hydrogen development.

Table 8.
Alignment between recurring water-related sustainability criteria for green hydrogen and current Chilean water governance, regulatory practice, and practice

Nº	CRITERIA	WHAT SUSTAINABILITY CRITERIA EXPECT	CHILE'S CURRENT SITUATION	PRELIMINARY ALIGNMENT
1	Water source transparency and documentation	› Clear disclosure of water source type, volumes, withdrawals, and discharges. › Information on water availability, seasonal variability, and baseline water stress.	› Environmental Impact Assessments (EIAs) require disclosure of water intake and discharge for industrial projects (Subsection 3.1).	Partially aligned
2	Water-use efficiency and minimisation	› Evidence of water-efficient project design and operation. › Measures to minimize losses, improve efficiency, and recycle water where feasible. › Monitoring or reporting of water use over time.	› No national benchmarks for hydrogen-related water efficiency. › Early H2 projects rely on industry best-practice but without regulatory guidance.	Uncertain/ emerging
3	Avoidance of competition with drinking water and essential local uses	› Consideration of impacts on water for human consumption and essential local uses. › Preference for avoiding or mitigating conflicts with communities, agriculture, and food security.	› Recent reforms to Water Code prioritizes human consumption, sanitation and environmental health (Subsection 3.1.2). › Early hydrogen project concepts indicate the use of desalinated water, but not yet formalised in hydrogen-specific guidelines. › There is no explicit hydrogen-specific ban on using inland freshwater yet, but strategies emphasise desalination and point to regulatory gaps (Subsection 3.3).	Partially aligned
4	Governance, permitting, and stakeholder participation	› Transparent permitting processes and approval processes. › Stakeholder and community engagement, including consultation mechanisms. › Procedures to address grievances and water-related concerns.	› Chile's EIA system includes public participation. › Stronger requirements apply in areas with Indigenous communities. › Capacity and trust differ by region.	Partially aligned
5	Long-term sustainability and cumulative impact	› Demonstrate of water availability over the project lifetime. › Consideration of cumulative impacts and long-term resource pressures.	› Current framework evaluates project-by-project impacts (Subsection 3.1.3). › National/regional water planning exists but is uneven, especially in coastal zones (Subsection 3.1.1).	Weak alignment
6	Environmentally responsible desalination and discharge	› Measures to minimize impacts on marine and coastal ecosystems. › Responsible management of brine and other discharges. › Environmentally sensitive intake and discharge design.	› Existing mining desalination plants follow Chilean EIA requirements for marine impacts (Subsection 3.1.3). › Cumulative impacts on some coastal zones remain insufficiently assessed.	Weak alignment

5.1 Interpretation of the Alignment Analysis: Strengths, Gaps, and Implications

This subsection interprets the results of the alignment analysis presented in Table 8 and examines their implications for Chile's emerging green hydrogen sector. Building on the assessment of partial and weak alignment across criteria, the discussion identifies areas where existing governance structures provide a foundation for sustainable hydrogen development, as well as areas where regulatory gaps, implementation challenges, or institutional limitations may constrain future compliance with international sustainability expectations.

5.1.1 Strengths and Areas of Alignment

Despite the identified gaps, the alignment analysis also highlights areas where Chile is comparatively well positioned.

Despite existing gaps, Chile's water governance framework demonstrates partial alignment with international sustainability criteria, particularly in terms of transparency, institutional procedures, and the prioritisation of essential water uses.

First, *water source transparency and documentation* are embedded in existing regulatory practice. EIAs require disclosure of water abstraction and discharge for industrial projects, and the system of DAAs provides a formal record of authorised withdrawals (Subsection 3.1). Although monitoring quality varies across regions, the institutional framework for documenting water sources and volumes is established and could serve as a foundation for more standardised reporting in the hydrogen sector. In addition, transparency related to desalination projects is partially supported by the Chilean Association for Desalination and Reuse (ACADES, 2025), which maintains a publicly accessible map of water-related projects across Chile. The platform provides information on project location, use, responsible companies, installed capacity (L/s), and estimated costs. However, it does not include systematic data on seawater abstraction volumes or effluent volumes.

Second, *governance, permitting, and stakeholder participation* are formalised components of Chile's environmental framework. The EIA system includes public participation mechanisms (SEA Chile, n.d.), and strengthened procedures apply where Indigenous communities may be affected (SEA Chile, n.d.). While capacity and trust differ regionally, the procedural architecture for consultation and grievance handling is in place and broadly consistent with international sustainability expectations.

Third, the recent reform of the Water Code strengthens conceptual alignment with the criterion of *avoiding competition with drinking water and essential local uses.* The legal prioritisation of human consumption, sanitation, and environmental protection provides a normative safeguard within water allocation decisions (Subsection 3.1.2). In parallel, early hydrogen project proposals and the *Chilean National Strategy for Green Hydrogen and Derivatives for 2026* (Ministerio de Energía, 2026) indicate a preference for desalinated seawater, reflecting awareness from the sector and the government of potential conflicts with inland freshwater resources (Subsection 3.3). However, this orientation is not yet formalised in hydrogen-specific regulation, and no explicit prohibition of freshwater use exists. As such, alignment remains partial and dependent on implementation and future sectoral guidance.

Taken together, these elements suggest that Chile possesses key institutional building blocks that align with international sustainability criteria. The main challenge lies less in the absence of governance structures and more in ensuring their consistent application and adaptation to the scale and spatial concentration of future hydrogen-related water demand.

5.1.2 Areas of Weak or Emerging Alignment

The alignment analysis suggests that Chilean has a significant gap concerning *long-term water sustainability and cumulative impacts*, as current regulatory processes continue to assess projects largely on an individual basis. Although EIAs require disclosure of water abstraction and marine impacts, they do not systematically evaluate cumulative pressures at the basin or coastal zone level, especially in areas where multiple desalination or industrial facilities may co-locate.

This limitation is closely linked to, *environmentally responsible desalination and discharge* which also shows weak alignment. Although Chile has extensive experience regulating individual desalination plants, particularly in the mining sector, cumulative impacts on marine and coastal ecosystems are not yet comprehensively assessed. As hydrogen-related desalination expands, particularly in regions with limited existing infrastructure such as Magallanes, this gap may become increasingly relevant for compliance with international sustainability expectations.

In addition, Chile is currently evaluating a proposed legal framework for desalination (Subsection 3.1.4). While this initiative could provide greater regulatory clarity regarding seawater abstraction, it does not establish specific brine effluent thresholds. (Subsection 3.1.5). At present, brine is not explicitly regulated under Chile's liquid effluent standards, and environmental assessments rely in part on the Australian ANZECC 1992 guidelines, which have since been superseded by updated "*Australian and New Zealand Guidelines for Fresh and Marine Water Quality*" ("Management framework," n.d.). This reliance highlights a regulatory area that requires modernisation as desalination capacity expands.

At the strategic level, ongoing planning initiatives may strengthen the treatment of cumulative and long-term water pressures in the future. The *National Plan for Public Infrastructure 2025-2055* (Gobierno de Chile, 2025), has as a focus multipurpose infrastructure and a resilient management of water, reinforcing basin-level sustainability considerations such as: decentralized management, hydric planification and resilience. Complementing this, Chile has introduced *Strategic Water Resource Plans for Watersheds (Planes Estratégicos de Recursos Hídricos en Cuencas, PERHC)* and associated *Strategic Water Resource Roundtables (Mesas Estratégicas de Recursos Hídricos, MERH).*

The PERHC function as formal basin-level planning instruments designed to identify surface and groundwater gaps, establish current and projected water balances, and propose adaptation measures to safeguard water security under climate change. The MERH operate as participatory platforms during the preparation and updating of these plans, facilitating coordination between public authorities and private stakeholders and supporting implementation of agreed measures (Ministerio del Medio Ambiente, n.d.).

Together, these instruments indicate a shift towards more integrated basin-level governance. However, their effectiveness in addressing cumulative impacts from emerging sectors such as green hydrogen will depend on their implementation, data quality, and the systematic incorporation of projected industrial water demand into planning processes.

5.1.3 Knowledge Gaps and Structural Limitations

Beyond the specific regulatory gaps identified above, the alignment assessment also reveals cross-cutting knowledge and structural limitations that affect Chile's ability to demonstrate full compliance with emerging water-related sustainability criteria.

Across several criteria, particularly water source transparency, long-term sustainability, and cumulative impacts, implementation is constrained by uneven data availability and monitoring capacity at the basin level. While formal systems for water allocation and environmental assessment are in place, persistent gaps remain regarding groundwater recharge rates, aquifer conditions, operational status of irrigation infrastructure, and comprehensive drought and flood inventories (HIDRICA Consultores, 2025). These limitations reduce the precision of coastal and river basin-level water balances and complicate the systematic evaluation of long-term resource availability.

Water quality monitoring presents similar challenges. In industrialised and agricultural basins, contamination by nitrates and heavy metals has been documented, which restricts available water uses and adds complexity to resource planning. However, data coverage and consistency vary regionally, limiting the ability to integrate quality constraints into cumulative impact assessments (Gobierno de Chile, 2025).

Institutional fragmentation further compounds these challenges. Despite recent reforms and new planning instruments, coordination between surface and groundwater management, sectoral authorities, and territorial actors remains uneven. Differences in technical capacity across regions may affect the consistent implementation of sustainability safeguards, particularly as new water-intensive sectors expand (Gobierno de Chile, 2025).

Taken together, these structural and informational constraints help explain why several criteria remain only partially aligned or weakly aligned. The challenge lies less in the absence of legal instruments and more in strengthening data systems, inter-institutional coordination, and coastal and river basin-level management to support sustainable scaling of green hydrogen development.

> The challenge lies less in the absence of legal instruments and more in strengthening data systems, inter-institutional coordination, and coastal and river basin-level management to support sustainable scaling of green hydrogen development.

6 CONCLUSION

This report assessed the alignment between recurring EU and international water-related sustainability criteria for green hydrogen and the current Chilean water governance and regulatory context. The analysis highlights both institutional strengths and structural limitations that will shape Chile's ability to meet evolving sustainability expectations as hydrogen production scales up.

The alignment analysis indicates that Chile is most likely to face scrutiny in relation to cumulative impacts and long-term water sustainability. Current EIAs processes remain largely project-based, and coastal and river basin-level integration of multiple desalination and industrial projects is not yet systematically implemented. Environmentally responsible desalination and discharge may also attract attention, particularly as brine management standards remain partially defined and cumulative marine impacts are not comprehensively assessed. In addition, while legal priority is granted to human consumption under the Water Code, no hydrogen-specific safeguards formally restrict the use of inland freshwater. As hydrogen projects expand, particularly in water-stressed regions, scrutiny may focus on how effectively allocation safeguards and desalination preferences are implemented in practice. Finally, uneven monitoring capacity, groundwater data gaps, and regional differences in institutional capacity may limit the ability to demonstrate compliance with international transparency and long-term sustainability expectations.

In parallel, Chile possesses significant institutional foundations that support alignment with international sustainability criteria. EIAs procedures are established and include public participation mechanisms, including strengthened consultation processes in Indigenous territories. The formal system of water rights (DAAs) provides a structured allocation framework, and recent reforms prioritising human consumption and environmental protection align conceptually with international expectations regarding avoidance of water-use conflicts.

The findings also indicate areas where international cooperation could support improved alignment. Strengthening coastal and river basin-level monitoring systems, groundwater data quality, and cumulative impact modelling would enhance long-term water sustainability assessments. Technical cooperation on desalination governance, including brine discharge standards and marine monitoring protocols, may also help address emerging scrutiny related to coastal impacts. Finally, developing sector-specific guidance for hydrogen-related water-use efficiency and reporting could improve transparency and comparability across projects.

6.1 Research Needs / Limitations

This assessment is based on publicly available documentation, announced project information, and existing regulatory frameworks. Several aspects could not be fully evaluated within the timeframe of this project.

- **Limited availability** of high-resolution river basin-level groundwater data and recharge estimates.
- **Uncertainty** regarding the operational timelines and final water sourcing strategies of announced hydrogen projects.
- **Incomplete public information** on cumulative marine impact assessments for existing and planned desalination facilities.
- **Lack of detailed data** on projected hydrogen-related water-use efficiency across different electrolyser technologies.
- **Evolving regulatory reforms** (e.g. desalination framework and basin planning instruments) whose final design and implementation remain pending.
- **No comparative analysis** of other global regions; sustainability criteria in other importing countries were not assessed.

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ANNEX

Table 9.
European and international policy, regulatory, certification, and literature sources screened for the analysis, classified by document type and indicating inclusion in the report

TYPE	DOCUMENT	IN REPORT
Communication	COM/2023/156–European Hydrogen Bank	Yes
Communication	COM/2023/161–Net Zero Industry Act (NZIA)	No
Directive	Directive (EU) 2024/1619–Amending Directive 2013/36/EU as Regards Supervisory Powers, Sanctions, Third-Country Branches, and Environmental, Social and Governance Risks	Yes
Directive	Directive (EU) 2024/1760–On corporate sustainability due diligence and amending Directive (EU) 2019/1937 and Regulation (EU) 2023/2859	Yes
Directive	Directive 2003/87/EC–Directive 2003/87/EC, incl. amendments covering CCU and RFNBOs	No
Directive	Directive (EU) 2010/75–Industrial Emissions Directive (IED)	No
Directive	Directive (EU) 2018/2001–On the Promotion of the use of Energy from Renewable Sources–RED II	No
Directive	Directive (EU) 2023/2413–Amending RED II with Updated Targets and Definitions–RED III	No
Directive	Directive (EU) 2012/18–On Control of Major-accident Hazards–Seveso III	No
Regulation	Regulation (EU) 2023/956–Carbon Border Adjustment Mechanism (CBAM)	No
Regulation	Commission Implementing Regulation (EU) 2022/996–Mass balance System Requirements Under RED II	No
Regulation	Regulation (EU) 2020/852–Establishment of a Framework to Facilitate Sustainable Investment, and Amending Regulation (EU) 2019/2088	Yes
Regulation	Regulation (EU) 2023/1184–Rules for RFNBOs and GHG Savings Criteria	No
Regulation	Regulation (EU) 2023/1185–Rules for Electricity Use in RFNBO Production	No
Regulation	Regulation (EU) 2023/1640–Methodology for Determining Renewable Share in Co-processing	No
Regulation	Regulation (EU) 2024/1735–Establishing a Framework of Measures for Strengthening Europe’s Net-Zero Technology Manufacturing Ecosystem and Amending Regulation (EU) 2018/1724	No
Regulation	Regulation (EU) 2021/947–Establishing the Neighbourhood, Development and International Cooperation Instrument–Global Europe	Yes
Certification	CertifHy	No
Certification	Climate Bonds Initiative	Yes
Certification	Green Hydrogen Organisation (GH2)	Yes

TYPE	DOCUMENT	IN REPORT
Certification	International Finance Corporation–Performance Standards on Environmental and Social Sustainability	Yes
Certification	ISCC EU	No
Certification	ISCC PLUS	No
Certification	RedCert EU	No
Certification	RSB Standard for Advanced Fuels v2.6	Yes
Certification	SURE–EU	No
Certification	TÜV SÜD Standard CMS 70, Version 07/2024	Yes
Position Paper	FuelsEurope Position Papers on Delegated Acts (2023)	No
Position Paper	Sustainability Criteria for Import Projects for Renewable Hydrogen and PtX Products (The German National Hydrogen Council, 2021)	Yes
Report	PtL Roadmap: Sustainable Aviation Fuel from Renewable Energy Sources for Aviation in Germany. (Pfeiffer & Spöttle, 2021)	No
Report	PtX.Sustainability Dimensions and Concerns (PtX Hub, 2022)	Yes
Report	Sustainability Dimensions of Hydrogen Production in Countries of the Global South (Krieger et al., 2024)	Yes
Scientific Article	Germany's Power-to-X Policy for Climate-neutral Transport (Torkayesh & Venghaus, 2024)	Yes
Scientific Article	Green Hydrogen Production: Integrating Environmental and Social Criteria to Ensure Sustainability (Blohm & Dettner, 2023)	Yes
Scientific Article	Sustainability Regulations for PtX Projects: Scope and Impact Analysis (Bube et al., 2025)	Yes

Table 10.
Avoidance of competition with drinking water and essential local uses

TYPE	NAME	SUPPORT
Communication	European Hydrogen Bank	Indirect
Directive	Directive (EU) 2024/1760	Direct
Regulation	Regulation (EU) 2021/947	Indirect
Certification	TÜV SÜD Standard CMS 70, Version 07/2024	Direct
Certification	Green Hydrogen Organisation (GH2)	Direct
Certification	Climate Bonds Initiative	Direct
Certification	RSB Standard for Advanced Fuels v2.6	Direct
Certification	International Finance Corporation–Performance Standards on Environmental and Social Sustainability	Indirect
Position Paper	Sustainability criteria for import projects for renewable hydrogen and PtX products (Nationaler Wasserstoffrat, 2021)	Direct
Position Paper	Sustainability dimensions of hydrogen production in countries of the Global South (Krieger et al., 2024)	Direct
Position Paper	PtX.Sustainability Dimensions and Concerns (PtX Hub, 2022)	Direct
Position Paper	Green hydrogen production: Integrating environmental and social criteria to ensure sustainability (Blohm & Dettner, 2023)	Direct

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