

Governance for a Sustainable Hydrogen Economy

A Review of the Current State of Play

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Executive Summary

Hydrogen is widely recognized as an energy carrier of the future. It is expected to play a key role in decarbonizing various industries and economic sectors, significantly contributing to global climate change mitigation efforts. Ensuring that hydrogen delivers its promised climate benefits is paramount. However, hydrogen production presents additional environmental and socio-economic challenges and uncertainties (Cremonese et al., 2023). Water-related risks are a case in point. While electrolysis-based hydrogen powered by renewable energy (referred to as renewable or green hydrogen) has the lowest greenhouse gas footprint (IRENA, 2022), the regions with the highest potential for its production are also frequently affected by water scarcity (see, for example, Terlouw et al., 2024).

Governance for the Sustainable Development of the Hydrogen Sector

A range of governance mechanisms have emerged that address sustainability challenges in the hydrogen sector. In this study, we refer to these as “sustainability governance”. These mechanisms aim to ensure the climate benefits of hydrogen, help mitigate environmental and social risks, and help secure benefits for the various actors along the value chain. In doing so, sustainability governance can facilitate the rapid scale-up of hydrogen infrastructure by securing support and ownership from all relevant stakeholders. Additionally, robust sustainability governance helps ensure transparency and fair competition by guaranteeing compliance by all economic actors with the same standards and safeguards (see figure I below).

FIGURE I: SUSTAINABILITY GOVERNANCE: PURPOSE AND OBJECTIVES



Source: Authors

In the emerging hydrogen sector, where rules, norms, and market structures are still in Uflux, sustainability governance is evolving at different levels of governance. Major players in the hydrogen economy, such as the U.S., the EU, China, and Japan are pursuing diverse approaches, ambitions, and strategies for integrating sustainability into their national agendas. This diversity of approaches provides opportunities for experimentation and for gathering lessons learned. At the same time, it creates fragmentation across jurisdictions and represents a potential barrier for creating and scaling-up markets.

Aim and Structure of the Report

This fragmentation of sustainability governance is mirrored in the existing literature on the topic. No attempt has been made at offering an overview of the sustainability

governance architecture as a whole. Moreover, the literature has largely ignored the fact that many generic governance mechanisms – that do not specifically target the hydrogen sector – can play an important role in upholding sustainability requirements. Against this background, this study provides a comprehensive overview of the emerging sustainability governance architecture in the hydrogen sector.

Chapter 2 presents key elements of a robust sustainability governance landscape and their most important characteristics. This conceptual framework forms the basis for characterizing and comparing key governance elements throughout the remainder of the report. Chapters 3, 4 and 5 provide a comprehensive overview of existing government strategies, regulations, and funding schemes in the European Union, the United States, and China, respectively. This overview is complemented by a small number of illustrative government funding schemes from other important countries presented in Chapter 6.

Chapter 7 provides a review of existing standards and certification schemes relevant to hydrogen sustainability. Chapter 8 focuses on how sustainability considerations are applied in due diligence processes in the financial sector, including public and private financial institutions. Chapter 9 presents selected high-level principles and supporting initiatives that provide orientation and guidance for sustainability-related governance mechanisms at the international level. The report concludes with Chapter 10, which provides a synthesis of the study's results and draws a number of policy-related conclusions.

Chapter 2: Sustainability Governance: Elements and Distinguishing Features

This report applies a sectoral perspective to sustainability governance, i.e. sustainability governance in the hydrogen sector. In this context, we define sustainability governance as the formal and informal rules and institutions, as well as the modes of coordination and steering that advance sustainability in the hydrogen sector. This encompasses aspects related to climate and broader environmental and social sustainability. Figure II on the following page provides an overview of the key elements that make up this governance landscape and that provide the structure for this report. For each of these elements, the report reviews a number of distinguishing features. It considers the sustainability dimensions covered, whether it is hydrogen-specific or generic in nature, whether it is binding or voluntary, as well as its scope (in terms of geography and value chain segments covered).

Chapter 3: Sustainability Governance in the EU

Chapter 3 presents the emerging hydrogen-related sustainability governance in the EU. The EU has developed the most comprehensive governance architecture for hydrogen sustainability, in many cases via generic instruments that do not exclusively target the hydrogen sector. The Renewable Energy Directive (RED) and its delegated acts, together with the EU hydrogen and gas decarbonisation package, constitute the only hydrogen-specific regulation with binding sustainability provisions. However, their scope is confined to climate and renewability aspects.

Beyond these two legislative packages, sustainability is embedded through broader EU regulatory instruments. Hydrogen projects at an industrial scale are subject to the Environmental Impact Assessment (EIA) Directive, which introduces both environmental safeguards and stakeholder participation elements. For projects receiving EU funding, additional requirements apply through the “Do No Significant Harm” (DNSH) criteria of the EU Taxonomy. The EU's Corporate Sustainability Due-Diligence Directive (CSDDD) requires companies to actively identify, prevent, and address adverse human rights and environmental impacts across their value chains. Although not hydrogen-specific, it establishes sustainability requirements along the hydrogen value chain. The EU also supports hydrogen sustainability indirectly through transparency and disclosure requirements.

Chapter 4: Sustainability Governance in the United States of America

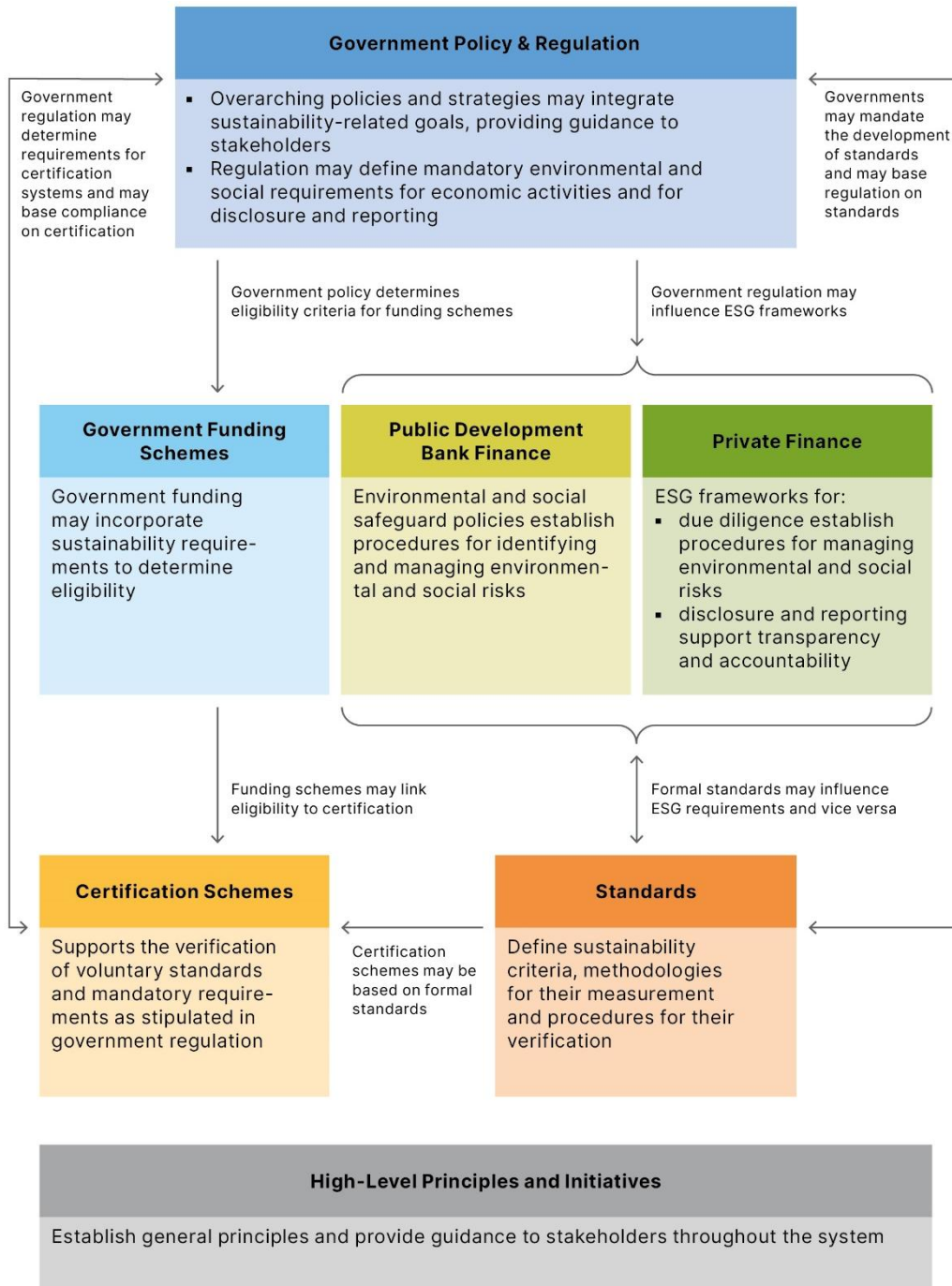
Like the EU, the U.S. does not have a dedicated regulatory framework for hydrogen sustainability. Federal policy introduced under the Biden administration has focused primarily on accelerating deployment and ensuring economic competitiveness through large-scale investments. The Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) provide the backbone of this approach, including tax credits under Section 45V (up to \$3/kg hydrogen) and substantial federal funding for seven regional Clean Hydrogen Hubs.

Sustainability considerations are incorporated primarily through climate-related provisions. The most prominent example is being implemented at the state-level. The California's Low Carbon Fuel Standard (LCFS) requires hydrogen to become fully renewable by 2035, making it the only U.S. regulation with a binding future requirement for renewable hydrogen.

Environmental safeguards are applied through the generic National Environmental Policy Act (NEPA), which mandates environmental assessments for federally funded or permitted projects.

Social dimensions are partly integrated into federal funding schemes. The Clean Hydrogen Hubs program incorporates environmental justice criteria, and the IRA tax credits include labor standards. That said, several measures to support hydrogen production have been withdrawn or are under review by the current U.S. administration. For example, certain funding allocations for the Clean Hydrogen Hubs have been cancelled. The 45V tax credit mechanism remains in effect in principle, although the deadline to start construction has been shortened to the end of 2027, strongly limiting its impact.

FIGURE II: SUSTAINABILITY GOVERNANCE IN THE HYDROGEN SECTOR: AN OVERVIEW OF KEY ELEMENTS



Source: Authors.

Chapter 4: Sustainability Governance in China

China’s governance of hydrogen is closely tied to its broader industrial and strategic priorities: technological leadership, energy security, and decarbonization. More recently, China’s commitment to renewable hydrogen has assumed increased visibility. For example,

certain state-owned enterprises have been mandated to pursue renewable hydrogen projects under the Green Low-Carbon Advanced Technology Demonstration (GLATD) program, even where projects are not financially viable.

A significant recent development is the introduction of the Clean and Low-Carbon Hydrogen Evaluation Standards. These standards define thresholds for GHG emissions across hydrogen production pathways and also establish criteria for hydrogen produced with renewable electricity. Compared with earlier schemes, these standards mark a shift toward regulatory consolidation and greater alignment with international practices. Compliance with these standards may become a prerequisite for major government funding or other governance schemes such as GLATD or the National Hydrogen Pilot Program. The latter provides long-term loans from the Chinese government for a wide range of projects across the hydrogen value chain - including, but not limited to, renewables-based hydrogen production.

China has also introduced sustainability disclosure and green finance frameworks, including the Corporate Sustainability Disclosure Standards (CSDS), aligned with the internationally recognized ISSB Standards, and a Green Taxonomy. The latter explicitly features a variety of hydrogen-specific activities. While structurally similar to the EU's instruments, China's taxonomy does not yet include explicit social safeguards. Broader sustainability dimensions—such as biodiversity, land and water use, or social equity—are not substantively integrated into hydrogen-specific governance and remain addressed primarily through general environmental law.

Chapter 6: Sustainability Requirements in Selected Government Funding Schemes

Chapter 6 highlights selected government funding schemes and their sustainability requirements - outside the United States, European Union, and China - that are relevant to the global hydrogen economy. The focus is on examples that make notable contributions to hydrogen sustainability or play a significant international role, regardless of whether sustainability is explicitly embedded in national strategies or formal governance structures.

In terms of the incorporation of sustainability requirements, the most notable example is the H2Global mechanism, which operates as a global market maker for hydrogen and hydrogen derivatives using a double-sided auction mechanism. In its auctions so far, its sustainability requirements are embedded in the Hydrogen Purchase Agreement, covering environmental, social, and governance dimensions, including conformity with the EU RED, human rights, water and land management, biodiversity protection, local value creation, and labor standards. Funded by multiple governments and open to projects worldwide, the H2Global mechanism exemplifies a sector-specific mechanism that promotes the hydrogen economy while ensuring adherence to environmental and social safeguards.

India's 'SIGHT' programme provides funding for renewable hydrogen and incorporates an ambitious GHG emissions threshold of 2 kg CO₂e per kg H₂, operationalized through the Green Hydrogen Certification Scheme India. Despite relatively narrow system boundaries, the scheme sets an ambitious emissions threshold and creates an emerging international benchmark for sustainable hydrogen production. Brazil's Low-Carbon Hydrogen Development Program (PHBC) provides tax credits to bridge the cost gap for low-carbon hydrogen, using a competitive auction system and a carbon intensity threshold of 7 kg CO₂e/kg H₂, one of the highest among major countries. Eligibility prioritizes projects that both reduce emissions and strengthen the national value chain, supporting domestic production and industrial development.

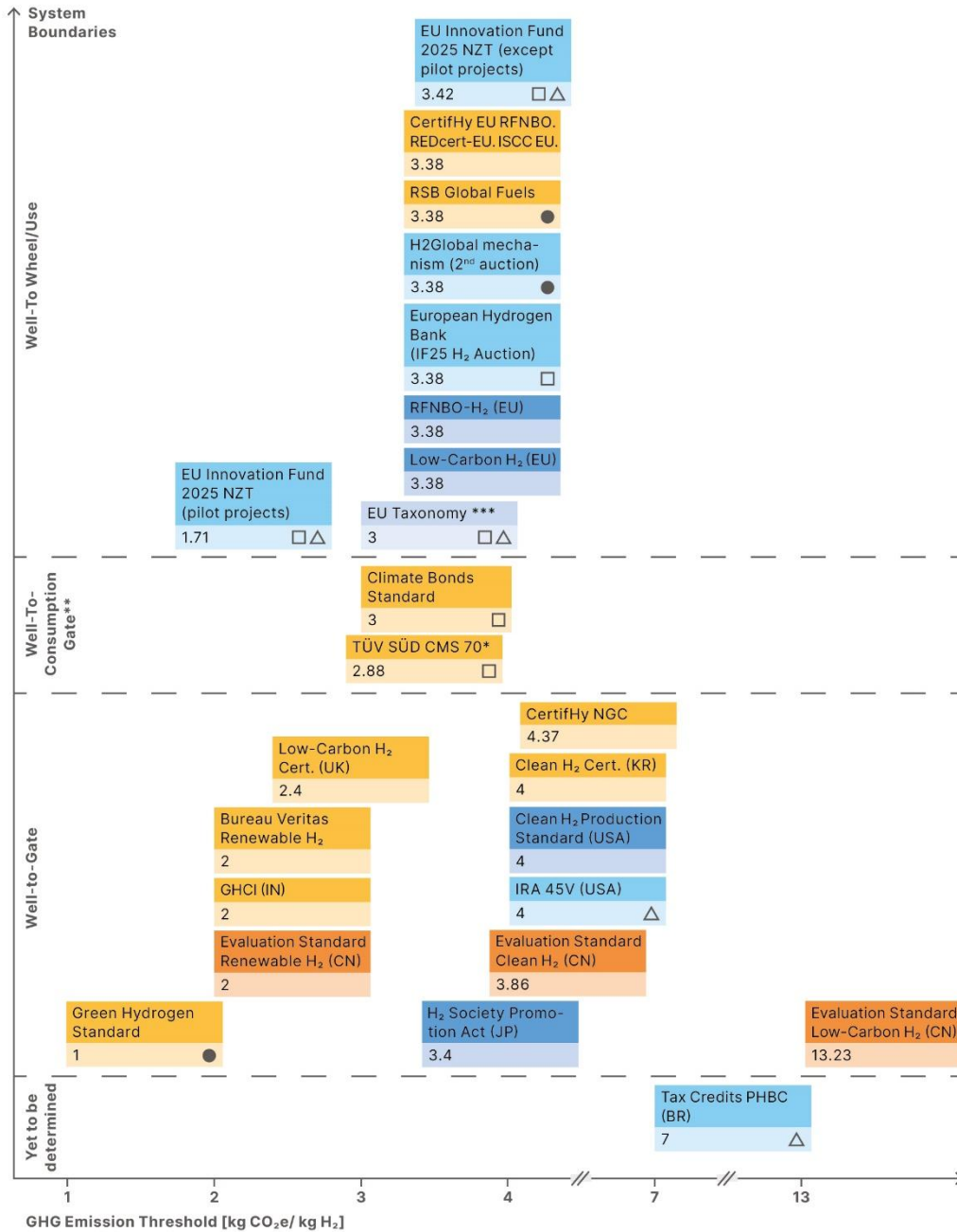
Chapter 7: Standards and Certification Schemes

Standards and certification schemes are central to quality infrastructure in the hydrogen sector, supporting transparency, credibility, and comparability across the value chain. Broadly, these frameworks fall into two categories: those addressing multiple dimensions of sustainability and those focused specifically on greenhouse gas emissions and decarbonization.

Sustainability-related standards and certification schemes include the draft standard by the German Institute for Standardisation (DIN) 35809:2025, the Green Hydrogen Standard and its certification scheme, and the RSB Global Fuels Certification. They cover environmental, social, governance, and economic aspects and establish requirements addressing GHG emissions, renewability, water and biodiversity management, human rights, labor conditions, and local economic benefits. Regional initiatives, like CertHiLAC in Latin America and the Caribbean, are emerging to align international market requirements with local environmental and social priorities.

GHG accounting standards and certification schemes concentrate on carbon intensity and specific eligible production pathways to support consistent reporting and regulatory compliance. Emerging approaches apply different GHG emission benchmarks and system boundaries (see figure III below), making them difficult to compare. In some cases, GHG benchmarks are combined with requirements to utilize only renewable energy as a primary energy source. ISO/TS 19870:2023 provides an internationally recognized approach for quantifying GHG emissions associated with hydrogen production, conditioning and transport. However, for the moment, regulatory schemes do not yet consistently build on the methodology that it proposes.

FIGURE III: OVERVIEW OF GHG ACCOUNTING CERTIFICATION SCHEMES AND STANDARDS



- Regulation of Economic Activities
- Transparency and Disclosure Mechanisms
- Government Funding Schemes
- Sustainability-Related Standards
- Sustainability-Related Certification Schemes
- Additional social & environmental dimensions (holistic approach)
- Additional environmental dimension (limited extent)
- △ Additional social dimension (limited extent)
- * Alternatively, a well-to-gate system boundary can be used. The threshold applies to heat, cooling, and steam applications, while a value of 3.38 applies to other hydrogen applications.
- ** ISO/TS 19870:2023 and IPHE use this approach
- ***While the EU Taxonomy permits alternatives, preference should be given to this system boundary

Source: Authors.

Chapter 8: Sustainability Governance of Hydrogen in Public and Private Finance

The ramp-up of the hydrogen economy requires substantial public and private investment. Beyond government support mechanisms, multilateral development banks (MDBs) already play a central role, providing financing and technical assistance across the nascent hydrogen value chain. MDB support is typically tied to environmental and social (E&S) frameworks, which use risk-based approaches including due diligence, exclusion criteria, impact assessments, stakeholder engagement, and mitigation measures. Widely cited by other governance instruments, the IFC Performance Standards serve as a benchmark for sustainability practices. These safeguards are particularly important for hydrogen projects, many of which rely on development bank financing. While some frameworks provide sector-specific guidance, dedicated hydrogen guidance has yet to be developed.

Private capital is equally critical to hydrogen deployment, making environmental, social, and governance (ESG) frameworks increasingly relevant. These frameworks either guide the management of ESG-related risks or require disclosure of ESG information to enhance transparency for investors and stakeholders. They operate at the financial institution level—informing investment decisions—and at the entity or project level—supporting reporting and accountability. While most ESG frameworks are generic and not yet hydrogen-specific, several are widely used by actors active in the hydrogen value chain, including the Equator Principles for ESG risk management and the IFRS, TNFD, and the Global Reporting Initiative for disclosures.

Chapter 9: High-Level Principles and Supporting Initiatives

High-level principles provide voluntary guidance to companies, governments, and investors on human rights, responsible business conduct, and sustainable investment. While not hydrogen-specific, they may provide reference points for sustainability governance in the hydrogen sector. These frameworks typically address social and human rights issues, anti-corruption, stakeholder engagement, and risk management, with some also covering environmental aspects. Examples include the UN Guiding Principles on Business and Human Rights, the UN Global Compact, the OECD Guidelines for Multinational Enterprises, and the UN Principles for Responsible Investment.

In addition, a range of supporting initiatives and projects has emerged to promote sustainable hydrogen practices in the hydrogen sector. UNIDO's Global Programme for Hydrogen in Industry (GPHI) and the International PtX Hub, funded by the German government, both serve as international platforms for knowledge exchange and capacity building, supporting the development of a sustainable hydrogen and PtX economy, respectively. Both have developed approaches for managing sustainability-related issues within the hydrogen sector. The Green Hydrogen Organisation is a multi-stakeholder initiative that provides dialogue and cooperation on sustainability-related issues. A core element of its work is the development and piloting of the Green Hydrogen Standard, a comprehensive sustainability framework and certification scheme specifically developed for green hydrogen and its derivatives.

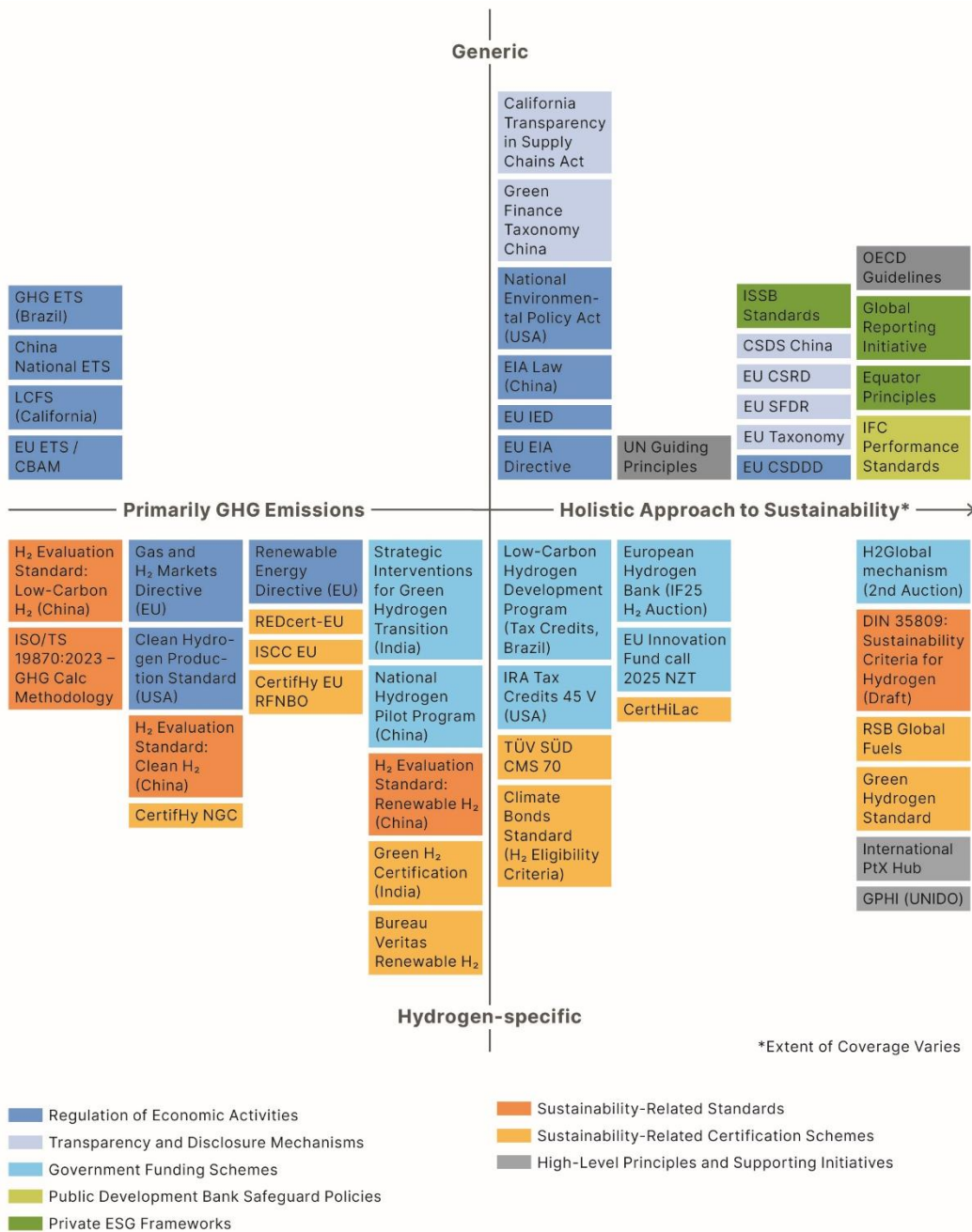
Chapter 10: Synthesis of Results and Policy Implications

Chapter 10 provides a review of the main results of the study and discusses a number of implications for policy. It begins by providing an overview of key elements of the sustainability governance landscape. Figure IV provides a mapping of the main governance mechanisms that promote or influence the sustainability of the hydrogen sector. It shows that a range of generic governance instruments adopts a multi-dimensional sustainability approach (upper-right quadrant). Here, the EU's CSDDD stands out as the main regulatory instrument that aims at directly upholding sustainability criteria within supply chains that extend beyond its own jurisdiction. In addition, financial institutions integrate generic due diligence requirements for ESG-related aspects. The most stringent requirements are found in multilateral development banks, such as the World Bank's International Finance Corporation (IFC).

Alongside these generic instruments, a variety of hydrogen-specific governance mechanisms have emerged. Many of these focus on GHG-related requirements (lower-left quadrant). This includes legislative packages such as the EU Renewable Energy Directive (RED), a number of certification systems (at the global and national levels), and hydrogen-specific GHG emission calculation methodologies, like ISO/TS 19870. Finally, a number of hydrogen-specific instruments take a broader approach (lower-right quadrant). These include initiatives in support of hydrogen, like UNIDO's Global Programme for Hydrogen in Industry, the International PtX Hub, as well as the Green Hydrogen Organisation and a number of certification schemes. In Germany, a draft sustainability standard for hydrogen

has been developed within the framework of its national standardization body, which might serve as a reference point for certifications in the future. Alongside certification schemes, sustainability requirements are integrated within public funding mechanisms like the EHB or the H2Global Mechanism, which has the most elaborate sustainability requirements so far.

FIGURE IV: CATEGORIZATION OF SUSTAINABILITY GOVERNANCE MECHANISMS IN THE HYDROGEN SECTOR



Source: Authors.

Recommendations for a Sustainable Hydrogen Ramp-Up

The findings of this study demonstrate that a wide array of governance mechanisms exists across major jurisdictions, with the objective of facilitating and promoting a sustainable hydrogen ramp-up. These mechanisms differ significantly in terms of the sustainability dimensions they cover, their voluntary or mandatory nature, and whether they influence the hydrogen sector directly or indirectly as generic sustainability governance mechanisms. Based on these findings, we derive a number of specific actionable recommendations.

Development of Hydrogen-Specific Guidelines for Sustainability-Related Due Diligence

The results of this study indicate that a range of generic instruments already exist to promote sustainability. To ensure that the potential of these generic governance instruments is fully realized, hydrogen-specific guidelines for due diligence procedures could play an important role. Such sector-specific guidelines would be particularly useful if they dovetailed with existing ESG frameworks and standards, while specifying the specific challenges of hydrogen-related investments.

A joint effort by the major multilateral development banks and key private finance institutions to further develop such guidelines could help establish a global reference for sustainability-related due diligence in the hydrogen sector. Jointly developed guidelines would not only support sustainability efforts by private sector actors, they would also support the harmonization of due diligence requirements being established by governments and financial institutions. The World Bank's Energy Sector Management Program or a similar knowledge hub at one of the multilateral development banks would be a suitable actor to lead such an initiative, while the Roundtable of Development Finance Institutions for Green Hydrogen, coordinated by the Green Hydrogen Organisation, could function as a forum for related discussion and alignment.

Development of an ISO Standard as an International Reference for Sustainable Hydrogen

Complementing the development of sector-specific guidelines, the development of an ISO standard for the assessment of sustainability in the hydrogen sector could further support the harmonization and alignment of approaches over time. By establishing an internationally agreed reference point, it could help promote consistency and comparability of sustainability-related requirements and schemes in the sector, including due diligence practices in the financial sector, certification schemes, and requirements within government funding schemes. To do so effectively, such a standard should build on existing approaches to sustainability-oriented due diligence, so that the resulting standard can foster increasing alignment of requirements, not only across countries but also across government and finance.

Strengthening Collaboration, Knowledge Exchange, and Capacity Building

Promoting and highlighting best practices in the implementation of sustainable hydrogen projects can also play an important role in supporting the ramp-up of the hydrogen economy. It can facilitate learning and build trust among stakeholders and the public. Moreover, it can enhance the ability of project developers to develop cost-effective approaches for complying with the due diligence required by financial institutions, thus facilitating their access to financial resources.

Activities should include the showcasing of exemplary projects and leveraging initiatives, such as the UNIDO's Global Programme for Hydrogen in Industry, the International PtX Hub, and the Green Hydrogen Organisation, to support capacity-building, knowledge sharing, and practical guidance in support of sustainable hydrogen production. Cross-border coordination and knowledge exchange are particularly important for regions with projected hydrogen import needs, such as the European Union, Japan, and South Korea, while potential exporting regions can also benefit from structured cooperation. The CertHiLac initiative is a case in point. It aims to combine the regulatory requirements of potential target markets with regional challenges and priorities. Once operational, it may illustrate how a certification system can align the interests of target import regions (e.g., the EU) with those of export regions (such as Latin America and the Caribbean).

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List of Abbreviations

ARSO	African Organisation for Standardisation
AVR	Accreditation and Verification Regulation
BIPM	International Bureau of Weights and Measures
CAB	Conformity Assessment Body
CATEX	Categorical Exclusion
CBAM	Carbon Border Adjustment Mechanism
CBI	Climate Bonds Initiative
CBP	Community Benefits Plan
CCER	Chinese Certified Emissions Reduction
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CEF	Corporate Environmental Footprint
CEN	European Committee for Standardization
CEQ	President's Council on Environmental Quality
CertHiLac	Clean Hydrogen Certification System for Latin America and the Caribbean
CHP	Combined heat and power
CHPS	Clean Hydrogen Production Standard (USA)
CoP	Communication on Progress
COPANT	Pan American Standards Commission
CSDS	Corporate Sustainability Disclosure Standards (China)
CSDDD	Corporate Sustainability Due Diligence Directive (EU)
CSRD	Corporate Sustainability Reporting Directive (EU)
CTSCA	California Transparency in Supply Chains Act
DIN	German Institute for Standardization
DNSH	Do No Significant Harm
DOE	U.S. Department of Energy
E&S	Environmental and Social
EC	Essential Criteria
EFRAG	European Financial Reporting Advisory Group
EHB	European Hydrogen Bank
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIS	Environmental Impact Statement
EPFIs	Equator Principles Financial Institutions
ESG	Environment, Social and Governance
ESMS	Environmental and Social Management System
ESRS	European Sustainability Reporting Standards
ETS	China National Emissions Trading System

ETS	Emissions Trading System
EU	European Union
FCVs	Fuel-Cell Vehicles
FMPs	Financial Market Participants
FONSI	Finding of No Significant Impact
GHCI	Green Hydrogen Certification India
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GLATD	Green Low-Carbon Advanced Technology Demonstration
H₂Uppp	International Hydrogen Ramp-Up Program
HPA	Hydrogen Purchase Agreement
IEC	International Electrotechnical Commission
IED	Industrial Emissions Directive (EU)
IFC	International Finance Corporation
IFRS	International Financial Reporting Standards
IIJA	Infrastructure Investment and Jobs Act (USA)
ILAC	International Laboratory Accreditation Cooperation
IPCEI	Important Projects of Common European Interest
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IRA	Inflation Reduction Act
ISEAL	International Social and Environmental Accreditation and Labelling Alliance
ISO	International Organization for Standardization
ISSB	International Sustainability Standards Board
LAC	Latin America and the Caribbean
LCFS	Low Carbon Fuel Standard (California, USA)
LCIA	Life Cycle Impact Assessment
MDB	Multilateral Development Banks
MNRE	Ministry of New & Renewable Energy (India)
MRR	Monitoring and Reporting Regulation
MRV	Monitoring, Reporting, and Verification
NCAAs	National Competent Authorities
NEA	National Energy Administration (China)
NEPA	National Environmental Policy Act (USA)
NGHM	National Green Hydrogen Mission India
OBBBA	One Big Beautiful Bill Act (USA)
OLADE	Inter-American Development Bank and the Latin American and Caribbean Energy Organization
PRI	Principles for Responsible Investment
QI	Quality Infrastructure
RECs	Renewable Energy Certificates
RED	Renewable Energy Directive

RFNBO	Renewable Fuel of Non-Biological Origin
RMT	Remedial Measures to Transition
RSB	Roundtable on Sustainable Biomaterials
SAF	Sustainable Aviation Fuel
SFDR	Sustainable Finance Disclosure Regulation (EU)
SIA	Social Impact Assessments
SLBs	Sustainability Linked Bonds
SOEs	State-owned enterprises
UNFCCC	United Nations Framework Convention on Climate Change
UNGPs	UN Guiding Principles on Business and Human Rights

1 Introduction

Hydrogen is widely recognized as an energy carrier of the future. It is expected to play a key role in decarbonizing various industries and economic sectors, significantly contributing to global climate change mitigation efforts. This is particularly relevant for industrialized nations. While some countries aim to produce and use hydrogen domestically, others - such as Germany and Japan - will heavily rely on hydrogen imports. This presents significant export opportunities for regions rich in renewable energy resources. Overall, the hydrogen economy offers potential for industrialization, value creation, and new trade flows in emerging economies, as well as decarbonization pathways for established industrial players (Eicke & De Blasio, 2022). As a result, the global hydrogen economy is often associated with creating win-win scenarios.

Ensuring that hydrogen delivers its promised climate benefits is paramount. However, hydrogen production presents additional environmental and socio-economic challenges and uncertainties. Water-related risks are a case in point. While electrolysis-based hydrogen powered by renewable energy (referred to as renewable or green hydrogen) has the lowest greenhouse gas footprint (IRENA, 2022), the regions with the highest potential for its production are also frequently affected by water scarcity (see, for example, Terlouw et al., 2024). This raises potential water-use conflicts. While seawater desalination offers a solution, it may generate harmful by-products such as brine.

Moreover, the large-scale use of land for renewable energy infrastructure and hydrogen production facilities may pose risks such as habitat disruption, ecological disturbances, and biodiversity loss. Hence, land use associated with this emerging energy carrier may give rise to potential conflicts over land and resource allocation. It is also essential to ensure that renewable energy deployment for hydrogen production does not compete with domestic renewable energy needs for electricity access. Furthermore, export-oriented investments in hydrogen production, particularly in the Global South, come with important global equity challenges and require balancing of interests between international investors and local populations to ensure social acceptance and prevent social and economic inequities (Cremonese et al., 2023).

1.1 Governance for the Sustainable Development of the Hydrogen Sector

A range of governance mechanisms have emerged that address the sustainability challenges in the hydrogen sector outlined above. In this study, we refer to these as “sustainability governance” (see Section 2 for a detailed description of its key elements). These mechanisms aim to ensure the climate benefits of hydrogen, help mitigate environmental and social risks, and help secure benefits for the various actors along the value chain. In doing so, sustainability governance can facilitate the rapid scale-up of hydrogen infrastructure by securing support and ownership from all relevant stakeholders. Additionally, robust sustainability governance helps ensure transparency and fair competition by guaranteeing compliance by all economic actors with the same standards and safeguards (see figure 1).

FIGURE 1: SUSTAINABILITY GOVERNANCE: PURPOSE AND OBJECTIVES



Source: Authors

In the emerging hydrogen sector, where rules, norms, and market structures are still in flux, sustainability governance is evolving at different levels of governance. Major players in the hydrogen economy, such as the U.S., the EU, China, and Japan pursue diverse approaches, ambitions, and strategies for integrating sustainability into their national agendas. The differences span multiple areas, from greenhouse gas emissions reduction strategies and preferred hydrogen production pathways (Cheng & Lee, 2022) to the stringency of environmental and social requirements (Gale et al., 2024; Goodwin et al., 2024). This diversity of approaches provides opportunities for experimentation and for gathering lessons learned. At the same time, it creates fragmentation across jurisdictions and represents a potential barrier for creating and scaling-up markets. This in turn is crucial for enabling reductions in costs and for making hydrogen a competitive option for decarbonizing hard-to-abate sectors like industry and long-distance transport.

This fragmentation of sustainability governance in practice is mirrored in the existing literature on the topic. Existing studies provide valuable insights on specific elements of sustainability governance, such as certification schemes and standards (see, for example, Gale et al., 2024; Goodwin et al., 2024), selected hydrogen-related public funding mechanisms (e.g., NewClimate Institute, 2025), or analyses of hydrogen-specific legislation at the European level (e.g., H4D Partnership, 2024; International PtX Hub, 2022). However, no attempt has been made at offering overview of the sustainability governance architecture as a whole. This is an important knowledge gap, since sustainability governance rests on a range of different, mutually supportive pillars (see Section 2 for more details). Moreover, the literature has largely ignored the fact that many generic governance mechanisms – that do not specifically target the hydrogen sector – can play an important role in upholding sustainability requirements. Efficient and effective sustainability governance in the hydrogen sector should not duplicate but rather build on such existing governance mechanisms.

Against this background, this study provides a comprehensive overview of the emerging sustainability governance architecture in the hydrogen sector. It examines existing governance mechanisms – internationally and across major economies - that promote sustainability directly and indirectly. This review addresses both climate-related aspects and other aspects of environmental and social sustainability. It places particular emphasis on the latter, as issues related to the reduction of greenhouse gas emissions have already received significant attention in previous studies. By examining commonalities, gaps, lessons learned, and country-specific approaches, this study aims to uncover strengths, weaknesses and potential opportunities and synergies for building a robust and efficient sustainability governance architecture. It concludes by highlighting concrete entry points for strengthening governance frameworks and advancing the sustainable development of the hydrogen sector.

1.2 Structure of the Report

Chapter 2 presents key elements of a robust sustainability governance landscape and their most important characteristics. This conceptual framework forms the basis for characterizing and comparing key governance elements throughout the remainder of the report. Chapters 3, 4 and 5 then provide a comprehensive overview of existing government strategies, regulations, and funding schemes in the European Union, the United States, and China, respectively. They examine how these elements of hydrogen governance address different dimensions of sustainability. This overview is complemented by a small number of illustrative government funding schemes from other important countries presented in Chapter 6.

Chapter 7 provides a review of existing standards and certification schemes relevant to hydrogen sustainability. Chapter 8 focuses on how sustainability considerations are applied in due diligence processes in the financial sector, including public and private financial institutions. Chapter 9 presents selected high-level principles and supporting initiatives that provide orientation and guidance for sustainability-related governance mechanisms at the international level.

The report concludes with Chapter 10, which provides a synthesis of the study's results and draws a number of policy-related conclusions. Among other things, it compares the different governance mechanisms considered in the report based on the sustainability dimensions covered and their degree of specificity to the challenges of the hydrogen sector, and will present some specific recommendations.

2 Sustainability Governance: Elements and Distinguishing Features

This chapter presents the concept of sustainability governance. It defines its key elements and features and relates them to the hydrogen sector. The resulting analytical framework provides the basis for a detailed review of sustainability governance in the hydrogen sector in the subsequent chapters, including a comparison across the EU, China and the United States.

2.1 Definition and Overview of Sustainability Governance

Despite longstanding debates on the role of governance for achieving sustainability (see, for example, Bosselmann et al. (2008) on ‘governance for sustainability’), there is no single, universally accepted definition of sustainability governance. Among other things, there is a distinction between approaches to be applied at the corporate level and higher-level approaches that address societal steering, involving governments and other societal stakeholders.

In the following report, we take a middle ground between these approaches and apply a sectoral perspective to sustainability governance, i.e. sustainability governance in the hydrogen sector. In this context, we define sustainability governance as the formal and informal rules and institutions, as well as the modes of coordination and steering that advance sustainability in the hydrogen sector. Moreover, sustainability encompasses the aspects related to climate and broader environmental and social sustainability. Overall, it refers to efforts that promote the development of the hydrogen sector, while ensuring the responsible management of environmental and social impacts, both positive and negative. This includes those aspects of both public and private governance that influence the enabling environment and incentives for promoting sustainability in the hydrogen sector. Notably, it does not, however, include corporate governance practices within individual organizations deploying relevant hardware (e.g., developers of hydrogen production projects), but rather focuses on institutions and actors with implications for the sector more broadly.

Sustainability governance includes the following elements:

Firstly, it involves **government policies and regulations** to promote sustainability in the hydrogen sector. Regulations may include both direct requirements imposed on actors and their activities in the hydrogen sector, and may include rules pertaining to reporting and transparency.

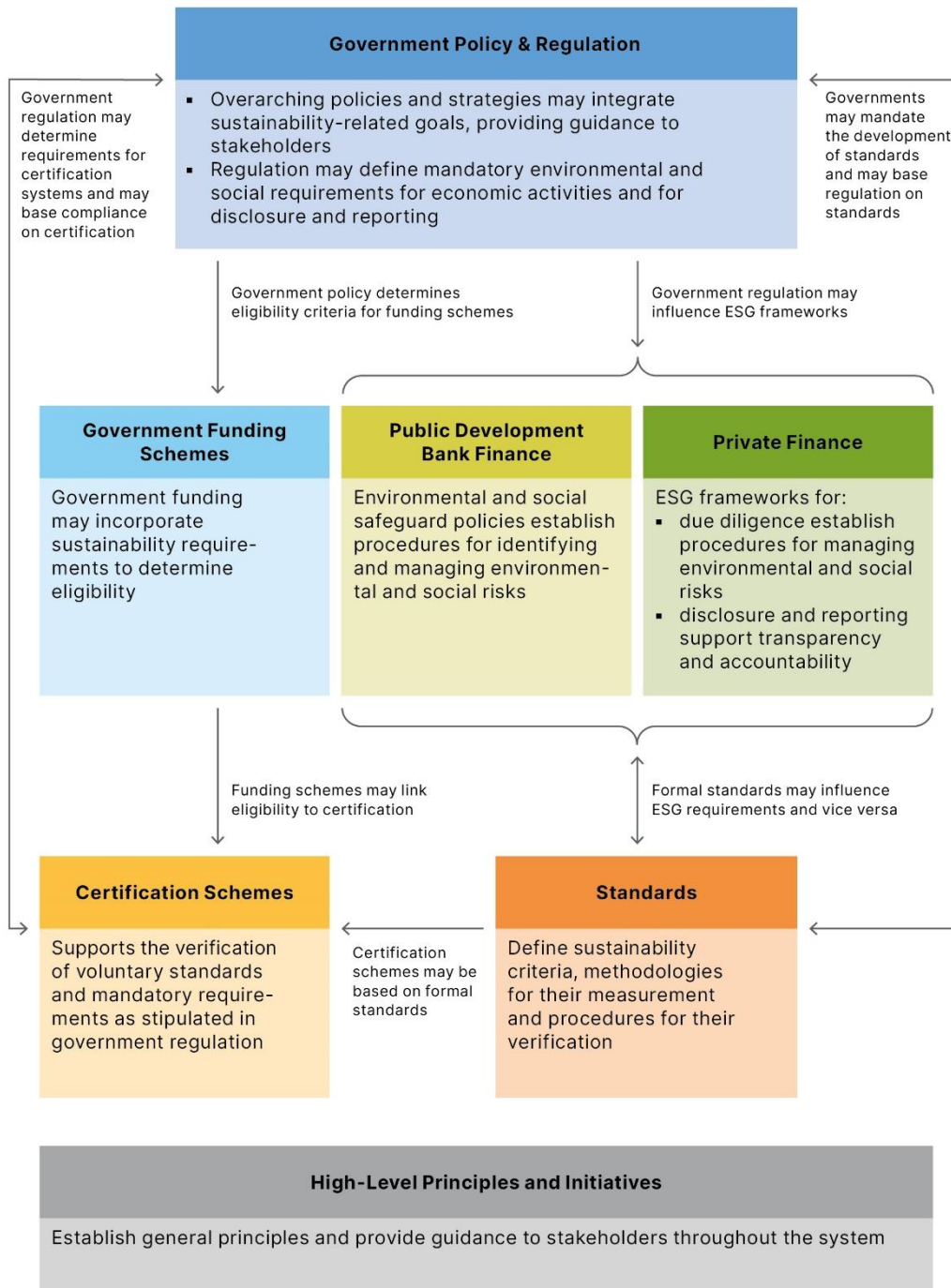
The report also **addresses sustainability-related rules and frameworks that are applied in the context of financing of hydrogen-related assets**. This could involve government funding schemes as well as financing from **public and private financial institutions**.

In addition, both private and public sector organizations frequently refer to and utilize standards and certification systems as the basis for defining and verifying sustainability-related requirements or claims. These are core elements of an emerging sustainability-related quality infrastructure in the hydrogen sector.

Finally, **high-level principles and initiatives** represent important reference points for developing approaches to sustainability governance. Many of these are not specific to the hydrogen sector. Nevertheless, they may offer orientation by providing general frameworks and criteria for firms and other stakeholders in the sector.

Figure 2 provides an overview of the elements outlined above.

FIGURE 2: SUSTAINABILITY GOVERNANCE: AN OVERVIEW OF KEY ELEMENTS IN THE HYDROGEN SECTOR



Source: authors

In Sections 2.2 to 2.4, we provide a brief introduction to the individual parts of the sustainability governance landscape in the hydrogen sector and what they comprise. We begin with government policy and regulation as well as government-sponsored funding schemes (Section 2.2), followed by sustainability governance in the financial sector, including public and private finance (Section 2.3). We conclude with a brief introduction to the concept of sustainability-related quality infrastructure with a particular focus on standards and certification schemes (Section 2.4). Section 2.5 discusses high-level principles and initiatives and their relevance for the hydrogen sector. The section concludes with a short overview of different governance characteristics that we utilize for a more fine-grained analysis of sustainability governance in the hydrogen sector in the remainder of the report (Section 2.6).

2.2 Governmental Policies, Regulations, and Funding Schemes

Governments play a central role in promoting hydrogen-related technologies and infrastructure. In this context, governments can deploy a number of different measures to promote and ensure the sustainable development of the hydrogen sector. These include:

1. Strategies and Overarching Policies

Strategies and overarching policies define the overall policy setting, including key policy targets and underlying principles. While these do not directly determine the activities and priorities of firms and other stakeholders in the hydrogen sector, they play an important role in providing orientation to sectoral stakeholders and represent important reference points for developing activities and taking investment decisions. The role given to sustainability-related goals and priorities in these documents is important in defining their role in the sector.

2. Regulation

Regulation of Economic Activities refer to classic regulatory instruments established by governments to ensure that defined environmental and social criteria are upheld in economic activities within the hydrogen sector.

Transparency and Disclosure Mechanisms include government-led initiatives designed to improve transparency regarding the environmental and social impacts of economic activities. Examples include financial taxonomies, which provide classification systems for sustainable economic activities. Such instruments enable investors to make informed decisions by offering insights into the sustainability attributes of products—such as the carbon intensity or environmental impact of hydrogen production. Another example is sustainability disclosure requirements policies, where legislation may mandate or encourage companies to report on the environmental and social impacts of their economic activities, potentially extending across their entire supply chain.

3. Government Funding Schemes

To address the current cost barriers associated with clean and green hydrogen production, support schemes are often designed to subsidize the 'green premium'—the additional cost relative to fossil-based alternatives. These schemes may also include climate- or sustainability-related criteria to determine eligibility.

2.3 Sustainability Governance in Public and Private Finance

Financial institutions play a critical role in supporting investment in the hydrogen sector. Their due diligence is central in determining whether hydrogen projects are considered viable and will receive the required financing to move forward. Over the past decades, actors in the financial sector have increasingly integrated sustainability criteria referred to as environmental, social, and governance (ESG) criteria in guiding investment decisions (EC, 2024b). These approaches for incorporating ESG criteria in the financial sector have resulted in the de facto obligation by companies and project developers to disclose increasing sustainability-related information and to implement measures that support the sustainability of the resulting ventures to acquire external finance.

Over time, a variety of ESG frameworks have been developed by financial institutions themselves as well as a variety of civil society organizations, international organizations, and multi-stakeholder initiatives dealing with these aspects. These operate at different levels and utilize different entry points to support the disclosure of sustainability-related aspects within companies (Siew, 2015). In the following, we provide an overview of approaches that have been developed by public development banks as well as by actors targeting private finance. The former play a particularly important role in funding investments in emerging clean technology sectors and also frequently function as a reference for other actors.

2.3.1 Environmental and Social Safeguards of Multilateral Development Banks

Public development banks play an important role in the development of the emerging hydrogen sector. They are involved in financing many of the projects in the early stages of market development. Multilateral development banks, such as the World Bank's International Financial Corporation or the European Investment Bank, are particularly influential, serving as reference points for other financial institutions. MDB mandates today extend to economic, social, environmental, and human rights dimensions (Mbengue & De Moerloose, 2017), and their operational policies, particularly Environmental and Social (E&S) Safeguard Policies, reflect this broader scope (Handl, 1998). Nowadays, most MDBs prioritize climate finance, identifying hydrogen as a key element in achieving the goals of the Paris Agreement (Hartmann et al., 2023, p. 1; Signoria & Barlettani, 2023). Several MDBs have already provided grants and finances for hydrogen projects and hydrogen-related activities. and they enforce strict environmental and social (E&S) safeguards.

MDBs enforce strong environmental and social (E&S) safeguard policies and may in some instances exceed national standards. MDBs follow a risk-based approach to sustainability governance (Blanc & Franco-Temple, 2013), assessing the likelihood and severity of risks associated with each project. This involves conducting a due diligence process, which may include borrower-provided information, MDB-conducted studies, site visits, and consultations with external experts. Projects are typically assigned risk categories (e.g., IFC Categories A–C), determining the extent of procedural requirements, such as Environmental and Social Impact Assessments, stakeholder engagement, grievance mechanisms, capacity building, and ongoing monitoring. The specific requirements and procedures of MDB environmental and social safeguards, and their relevance to hydrogen-related activities, are reviewed in Chapter 8.1.

2.3.2 ESG Frameworks in Private Finance

We identify two main types of ESG frameworks:

ESG Disclosure and Reporting Standards (company-level) aim to improve transparency and consistency in how ESG-related information is reported at the company level. They support investors in making better-informed decisions and enhancing accountability.

ESG Frameworks for Managing Social and Environmental Risks (project-level) go beyond disclosure to provide tools and procedures for identifying, managing, and mitigating environmental and social risks in specific investment projects. They are often developed by multilateral institutions, industry associations, or individual financial institutions (e.g., banks). Commonly applied in project finance, these instruments guide decision-making and ensure that sustainability risks are adequately addressed before and during investment.

Another important dimension of these approaches is linked to how they treat the concept of materiality. This refers to the type of sustainability impacts that the frameworks consider. Originally, ESG frameworks focused exclusively on financial materiality, which considers how sustainability risks affect financial performance or investments. Subsequently, approaches were developed that address so-called impact materiality, which considers the effects of investments on environmental and social outcomes. The increasingly adopted double materiality approach integrates both perspectives¹.

2.4 Sustainability-Related Quality Infrastructure: Standards and Certification Schemes

Next to sustainability-related requirements imposed by governments and financial institutions, sustainability-related quality infrastructure (QI) plays an important role in defining sustainability-related standards and ensuring robust and effective systems for verifying compliance with sustainability criteria (Ferdinand, 2023). The multi-stakeholder International Network on Quality Infrastructure defines QI as “the system comprising the organizations (public and private), together with the policies, relevant legal and regulatory framework, and practices needed to support and enhance the quality, safety and environmental soundness of goods, services and processes” (INetQI, 2025). Its core components include institutions and processes for metrology, standardization, accreditation, conformity assessment (including certification), and market surveillance (ibid.).

¹ The IFRS Foundation, the parent organization of the ISSB Standards, clarifies that the term 'materiality' primarily applies to financial statements and does not directly correspond to disclosures about financial activities (IFRS, 2024b, p. 17). For simplicity, however, the term 'materiality' is used in this study to cover all types of ESG frameworks discussed.

QI systems are typically developed at the national level but are embedded in and aligned with international structures. Key global institutions include the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Bureau of Weights and Measures (BIPM), and the International Laboratory Accreditation Cooperation (ILAC). At the regional level, organizations such as the European Committee for Standardization (CEN), the African Organisation for Standardisation (ARSO), and the Pan American Standards Commission (COPANT) play important roles in strengthening QI frameworks and promoting harmonization across borders (IRENA, 2024a).

In this report, we focus particular attention on the role of standards and certification schemes for defining and verifying different dimensions of sustainability in the hydrogen sector. In the hydrogen sector, sustainability-related standards establish sustainability criteria for products, components, practices, and services across the value chain, and they provide a shared foundation for market access and international trade (IRENA, 2024a). Sustainability certification schemes verify compliance with defined standards and foster trust within the emerging hydrogen economy (IPHE & IEA H₂ TCP, 2023). Certification schemes may be based on standards defined by government regulation, by industry actors, or by certifiers themselves. Collectively, standards provide essential information that fosters trust and facilitates cooperation and trade. When combined with certification schemes, they help reduce information asymmetries by signalling product quality, sustainability performance, and best practices, thereby supporting development (World Bank, 2025).

The following sub-sections provide a brief overview of the role of sustainability-related standards and certification schemes in the emerging hydrogen sector.

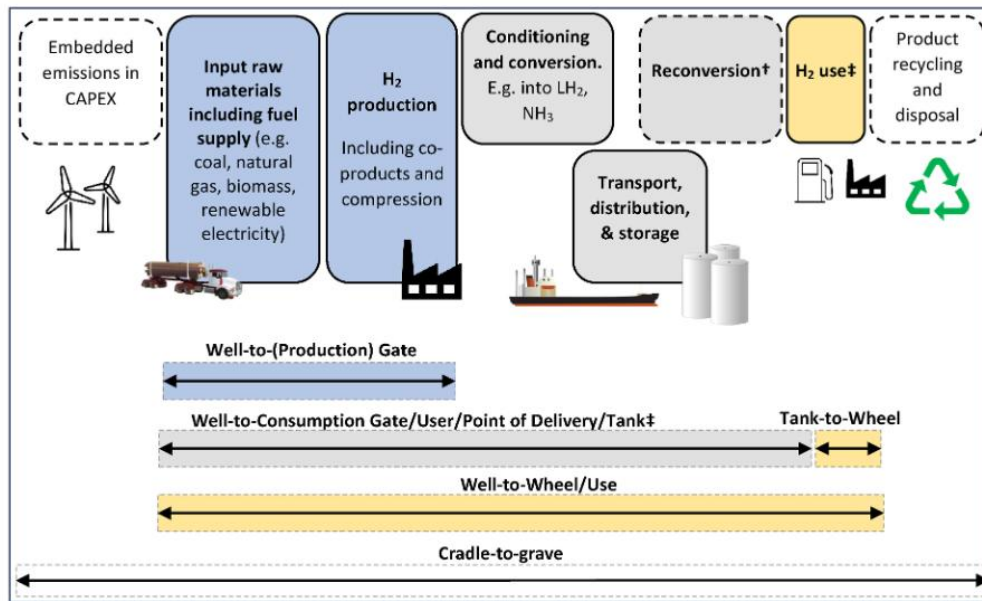
2.4.1 Sustainability-related Standards

The International Organization for Standardization (ISO) defines a standard as “a document, established by a consensus of subject matter experts and approved by a recognized body that guides the design, use, or performance of materials, products, processes, services, systems, or persons” (IPHE & IEA H₂ TCP, 2023). Standards are voluntary instruments that provide a formalized framework for defining system characteristics. They may include procedures for evaluation and conformity assessment, terminology and definitions, and criteria for compliance (as laid out in a QI system as above). Standards may be developed nationally—by organizations such as DIN (Germany) or AENOR (Spain)—but are often harmonized through collaboration with supranational organizations like ISO, which currently brings together 173 national standardization bodies. Regional organizations also play a role, such as CEN and CENELEC in Europe or ANSI in the United States (Velazquez Abad & Dodds, 2020). Such alignment facilitates trade, enhances comparability, and fosters consistency across markets.

Sustainability-related standards may define criteria for assessing and verifying across one or several dimensions of sustainability. Typical elements include requirements for calculating and determining greenhouse gas emission intensity, environmental performance, or other sustainability-related attributes. By establishing a consistent basis for measurement and comparison, sustainability-related standards enhance transparency and support the assessment of these attributes. They also facilitate interoperability across regions and sectors, thereby aligning market actors. Ultimately, they offer a common reference framework for stakeholders across the value chain - including producers, end-users, and investors - supporting the development of the hydrogen economy while integrating environmental protection and, to a lesser extent, social considerations (Ferdinand, 2023).

One important aspect for ensuring comparability is the definition of clear system boundaries, as environmental impacts—such as greenhouse gas emissions—can arise at various stages along the value chain, from feedstock production to downstream processes (White et al., 2021). Emissions also occur during the construction and decommissioning of production facilities (Velazquez Abad & Dodds, 2020). Furthermore, hydrogen itself acts as a greenhouse gas and may contribute to environmental impacts if leaks occur at any stage of the supply chain (Mar et al., 2024). These considerations are equally important for other environmental and social impacts, for example, that may arise beyond the hydrogen production gate, for example, during transportation, including maritime shipping. These considerations highlight the importance of clearly defined system boundaries, which are illustrated in figure 3.

FIGURE 3: SYSTEM BOUNDARIES IN A HYDROGEN VALUE CHAIN



Source: Authorized Copy from Gale et al. (2024)

Finally, the term “standard” is used widely to refer to different types of frameworks or requirements, including government regulations (e.g., California’s Low Carbon Fuel Standard) or entire certification schemes (e.g., the Green Hydrogen Standard). In this study, however, we use the term to refer to documents developed by recognized standardization bodies. Regulatory requirements are addressed in the chapters on government regulation and support schemes.

2.4.2 Sustainability-related Certification Schemes

Sustainability-related certification plays a critical role in verifying the sustainability of hydrogen production, ensuring compliance with defined standards, and fostering trust within the emerging hydrogen economy (IPHE & IEA H₂ TCP, 2023). Sustainability-related certification is a formal process conducted by accredited third-party bodies to validate that hydrogen production adheres to specified sustainability criteria, encompassing both environmental and socio-economic aspects. In the context of energy and sustainability, certification schemes can broadly be categorized into two types, primarily depending on the extent to which sustainability dimensions are addressed (IPHE & IEA H₂ TCP, 2023). Energy Attribute Certificates provide transparent information on the origin of renewable energy, including source, date, and location of production (e.g., Guarantees of Origin or Renewable Energy Certificates), while Sustainability Certificates provide evidence of broader sustainability attributes and will primarily focus on this study.

A robust certification scheme comprises several interconnected elements: a clearly defined standard, independent assessment, a defined validity period, and a transparent governance structure (ISEAL, 2023a). The governance approach of a certification scheme plays a foundational role in its overall effectiveness. To ensure credibility, schemes must emphasize the accuracy and reliability of information while promoting transparency and impartiality. This is often achieved through meaningful stakeholder engagement. Adaptability is also crucial to accommodate evolving legislation or standards. Meta-governance frameworks, such as those offered by the International Social and Environmental Accreditation and Labelling Alliance (ISEAL), provide valuable guidance. ISEAL’s ‘Code of Good Practice for Sustainability Systems’ (2023a) sets best practices for governance, stakeholder involvement, and sustainability strategies, enabling certification schemes to align with recognized standards, while ensuring robust implementation and oversight.

2.5 High-Level Principles and Initiatives

In addition to the different governance frameworks and elements described in this report, there are high-level principles and supporting initiatives that provide guidance to promote positive sustainability outcomes across a wide range of economic and financial actors. These principles serve as guiding frameworks that shape decision-making, behavior, and operational practices, helping organizations embed sustainability considerations into their core strategies. They offer companies and other actors a structured approach to align

their operations with sustainability objectives and enable financial institutions to integrate ESG factors both broadly and in specific investment strategies. High-level principles are designed to be broadly applicable across industries and regions, providing flexibility to be adapted to different contexts.

Although adherence is generally voluntary, in some cases entities that commit to these principles are expected to implement corresponding internal governance and compliance mechanisms to ensure credibility, transparency, and alignment with the stated objectives. In other cases, they include activities to promote knowledge exchange and capacity building. Importantly, these principles and initiatives complement existing legal and regulatory requirements, supporting organizations in achieving sustainable outcomes without replacing mandatory obligations.

2.6 Characteristics of Sustainability Governance Mechanisms

As discussed above, sustainability governance mechanisms consider a diverse set of sustainability dimensions, target different types of actors, and address different segments of the hydrogen value chain. They also differ based on the voluntary or binding nature of their requirements, and whether they apply to hydrogen specifically or whether they were developed as generic frameworks that are finding application in the hydrogen sector. In the following, we briefly review these different characteristics, which then serve as the framework for structuring the more detailed empirical review of sustainability governance approaches in the remainder of this report. Although not the primary focus of this study, general governance approaches, including processes for monitoring, verification, and compliance, are also important and are considered where relevant.

2.6.1 Sustainability Dimensions Covered

Climate

Climate-related aspects, most notably the greenhouse gas footprint of hydrogen and its contribution to greenhouse gas reduction, are central drivers of the hydrogen sector as a vehicle for the decarbonization of a number of end-use sectors. It is therefore essential to examine whether governance instruments explicitly address climate impacts and carbon intensity.

Renewability

In addition to greenhouse gas emissions, the phase-out of fossil fuels has been agreed as a central goal within the United Nations Framework Convention on Climate Change (UNFCCC). Hence, the extent to which hydrogen production relies on renewable energy is another factor that is considered in the context of sustainability governance. This includes considerations of whether hydrogen investments contribute to the expansion of additional renewable energy capacities or whether they rely on existing renewable or other energy sources.

Environmental Impacts

Large-scale hydrogen production also poses environmental risks. For example, more than 60% of electrolytic hydrogen production potential (onshore) is located in water-scarce regions, according to Terlouw et al. (2024), raising concerns about water consumption². Land use and biodiversity impacts are also relevant, especially given the spatial intensity of renewable-based hydrogen production (e.g., wind and solar power compared to fossil fuels).

Social Impacts

Social dimensions include the protection of human rights, promotion of local value creation, and avoidance of socio-environmental conflicts, particularly in resource use. Governance mechanisms should ensure that local interests are considered and that sustainability is inclusive. See Blohm and Dettner (2023) for other sustainability criteria relevant for the hydrogen sector.

Governance mechanisms may address one or several of these sustainability dimensions. This publication analyzes how each relevant instrument incorporates these elements.

² Remark: Next to electrolytic hydrogen, various other hydrogen production pathways have similar water footprints (see, for example, Henriksen et al., 2024)

2.6.2 Hydrogen-Specific vs. Generic

Sustainability instruments can also be distinguished by their scope of application. Hydrogen-specific approaches and instruments are explicitly designed for the hydrogen sector and include dedicated criteria or guidance covering production, transport, or trade. Generic sustainability approaches and instruments target broader sectors (e.g., energy, infrastructure). Though not developed for the hydrogen sector, they may nonetheless apply to hydrogen-related activities.

2.6.3 Binding vs. Voluntary

Governance instruments can be either mandatory or voluntary. Mandatory instruments include regulatory requirements such as obligations for hydrogen producers to meet specific sustainability criteria or disclose sustainability-related data. Voluntary instruments encourage sustainable practices without legal enforcement, often relying on market incentives or reputational drivers. These may range from detailed guidelines to broad, high-level principles. While generally voluntary in nature, adherence to certain elements may become mandatory in practice—for instance, when entities publicly claim to comply with these principles or guidelines.

2.6.4 Scope

Finally, governance mechanisms differ in their scope, both in terms of the segments of the hydrogen value chain that are covered (e.g., production, transport, consumption) and in terms of geography or administrative jurisdiction. Understanding the scope of specific instruments is essential for building a coherent and interoperable sustainability governance landscape.

3 Sustainability Governance in the EU

This chapter presents the emerging hydrogen-related sustainability governance in the EU. Based on the framework presented in Chapter 2, it reviews strategies, policies, regulations and funding schemes in the European Union that influence sustainability outcomes in the hydrogen sector. This includes both hydrogen-specific governance mechanisms and broader sustainability governance with implications for the hydrogen sector.

3.1 EU Hydrogen Strategy and Overarching Policies

The European Union (EU) has developed a comprehensive array of mechanisms, initiatives, and strategy documents that integrate hydrogen as a critical component of its energy transition efforts. These efforts outline both the strategic importance of hydrogen and the actions needed to accelerate its adoption.

The EU's Hydrogen Strategy of 2020 established a foundational framework for promoting and deploying renewable hydrogen. Renewable hydrogen, as defined in the document, includes electrolytic hydrogen produced using renewable energy sources, as well as hydrogen generated through biogas reforming or biochemical conversion of biomass. The strategy outlined key actions designed to foster investment and create an enabling, supportive regulatory framework, with a strong emphasis on market development. However, it dedicated comparatively less focus to sustainability-related considerations. While renewable hydrogen was prioritized, the strategy also permitted the integration of other production pathways to ensure flexibility and scalability. It emphasized the advancement of hydrogen technologies and the promotion of electrolytic hydrogen from renewable energy sources, contributing to reduced carbon emissions. Despite these efforts, the strategy placed limited emphasis on broader environmental and social impacts beyond its core objectives (EC, 2020).

The 2022 REPowerEU Strategy set ambitious targets, including the domestic production of 10 million tonnes of renewable hydrogen and the annual import of an additional 10 million tonnes by 2030. By 2050, hydrogen is forecasted to meet approximately 13-14% of the EU's energy mix (ibid.), playing a pivotal role in decarbonizing energy-intensive industries and the transport sector. Hydrogen is positioned as a cornerstone of the EU's energy transition, net-zero ambitions, and sustainable development goals. This plan is also part of the EC's 'Fit-for-55' plan, that set out Europe's plan for Europe to reduce the continent's greenhouse gas emissions by 55 % by 2030.

3.2 Regulation of Economic Activities

Key Highlights for Hydrogen Sustainability

EU RED and Delegated Acts

- Define how hydrogen must be produced to count toward the EU's renewable hydrogen production and import targets.
- Hydrogen qualifies as an RFNBO if produced via electrolysis powered by renewable energy, complying with additionality, temporal correlation, and geographical correlation rules.
- Establish a 70% GHG-emission reduction compared to the fossil comparator, corresponding to a GHG intensity threshold of 3.38 kg CO₂e/kg H₂.
- Introduce binding sectoral targets, e.g., 42% of hydrogen in industry from RFNBOs by 2030 and 14.5% GHG-intensity reduction in transport fuels.

EU Hydrogen and Gas Decarbonisation Package

- Sets rules for low-carbon hydrogen from non-renewable sources, including fossil-based hydrogen with CCS/CCU and electrolytic hydrogen using grid electricity, if the emission threshold is met. Nuclear-based electricity may be assessed for eligibility in the future.
- Maintains the 70% emission-reduction requirement and 3.38 kg CO₂e/kg H₂ GHG threshold.
- Emission thresholds may be tightened in future revisions to reflect technological progress.

EU ETS

- Applies a carbon price to a wide range of fuels produced within the EEA to also incentivize the adoption of hydrogen-based fuels with a lower carbon footprint.
- Covers also hydrogen production facilities with output greater than 5 tonnes of hydrogen per day, beginning in 2026.

EU CBAM

- Applies a carbon price to imported goods entering the EEA, including fuels and hydrogen-derived products such as fertilizers, ammonia, and hydrogen itself.
- The carbon price of hydrogen applies, for hydrogen, solely on direct emissions, with no differentiation between grid-based hydrogen and hydrogen produced using renewable electricity; distinctions apply to other hydrogen production pathways.

EU EIA Directive

- Requires public and private projects that may have significant environmental effects to undergo an Environmental Impact Assessment prior to receiving development consent.
- Hydrogen production in the EU, at industrial scale and at integrated chemical facilities (hydrogen produced for commercial use), must undergo an EIA in accordance with the directive's requirements. EIA Directive to be revised throughout 2026 to simplify environmental assessment procedures.

EU Industrial Emission Directive

- Regulates pollutive emissions to air, water, and land, and addresses waste, energy efficiency, and accident prevention (e.g., SO₂, NO_x).
- Hydrogen-producing plants must obtain environmental permits based on Best Available Techniques (BAT): electrolytic hydrogen above 50 tonnes/day, and all other pathways from the first tonne.

EU Corporate Sustainability Due Diligence Directive (CSDDD)

- Mandatory for large companies exceeding employee or turnover thresholds in the EU, likely including players active in the hydrogen value chain.
- Provides a generic due diligence framework to identify, mitigate, and manage human rights violations and environmental harm.
- The revised directive, published in February 2026, grounds this framework in a risk-based scoping exercise, prioritizing the areas where impacts are most severe or more likely to occur.
- The directive proposes the development of sector-specific guidelines to support compliance.

EU Renewable Energy Directive (RED)

A key element of the EU's strategy to promote the renewable hydrogen economy is the Renewable Energy Directive (EU RED). In November 2023, the third amended version of the directive (Directive (EU) 2023/2413 - RED III) entered into force.

RED III sets the overall EU renewable energy framework with a target of 42.5% renewable energy by 2030 across all sectors and includes binding sectoral targets for renewable hydrogen (RFNBOs): by 2030, 42% of hydrogen used in industry must come from RFNBOs, rising to 60% by 2035. For transport, the directive requires either a 14.5% reduction in GHG intensity of renewable fuels or at least a 29% share of renewables in final energy consumption, including a combined sub-target of 5.5% for advanced biofuels and RFNBOs, with a minimum of 1% RFNBOs by 2030 (H4D Partnership, 2024).

RED III specifies the term 'Renewable Fuels of Non-Biological Origin' (RFNBO), which are defined as "liquid and gaseous fuels whose energy content is derived from renewable sources other than biomass" (Article 2 (36)). Hydrogen meets the criteria for classification as such a gas, and any hydrogen that qualifies as an RFNBO is considered renewable hydrogen. To ensure compliance with the RFNBO classification, the European Commission has adopted two delegated acts (initially introduced under RED II, CDR 2023/1184 and CDR 2023/1185) that define the conditions hydrogen producers must meet for their product to be counted as an RFNBO.

Hydrogen producers may demonstrate compliance with the RED and its delegated acts through certification schemes recognized by the European Commission. As described in the Commission Implementation Regulation (EU) 2022/996, such schemes must feature inclusive governance, involving stakeholders such as farmers' and foresters' associations, environmental NGOs, local communities, academia, and fuel producers. They are also required to implement robust internal monitoring, complaint-handling mechanisms, transparent operations, and credible audit procedures. The regulation also aims to clarify the interoperability of certification schemes within the supply chain. If a segment uses a different voluntary scheme—for example, one focused on sustainability or traceability—it must be officially recognized by the European Commission. As of mid-March 2026, the EU recognizes REDcert-EU, CertifHy EU RFNBO, and ISCC EU as valid schemes for RFNBO certification, all of which primarily focus on GHG emissions (see also Chapter 7.2). The RED is scheduled for review by July 2028.

To enhance transparency and traceability, industry and certification holders are required to use a Union database (Article 18 of RED III). This database shall track sustainability attributes and GHG performance of liquid and gaseous fuels across the full supply chain, including feedstock origin, and is designed to prevent double-counting of certified products across borders.

Sustainability Dimensions Covered

The concept of additionality aims to ensure that hydrogen is produced almost exclusively from renewable energy sources and that this production does not compete with the broader expansion of renewables for general electricity supply. Temporal correlation is intended to prevent hydrogen production from encouraging the use of fossil-based electricity during peak demand periods, as electrolysis capacity connected to the grid may draw power from the local bidding zone. Geographic correlation ensures that renewable electricity is generated in proximity to where the hydrogen is produced - preventing situations where, for example, solar power is generated in one country but counted as "green" while hydrogen is produced elsewhere using fossil electricity (Delegated Act CDR (EU) 2023/1184). Together, the RED and its delegated acts ensure that hydrogen meets the requirement of renewability.

In addition to the outlined criteria, a renewable fuel of non-biological origin (RFNBO) must achieve a minimum 70% reduction in greenhouse gas (GHG) emissions compared to a defined fossil fuel comparator. For hydrogen, this comparator is set at 94 gCO₂e/MJ, which translates to a maximum of 3.38 kg CO₂e/ kg H₂ (LHV: 120 MJ/kg H₂). The GHG calculation methodology follows a well-to-wheel lifecycle approach, encompassing emissions from raw material inputs, production, transport, and end use (Delegated Act CDR (EU) 2023/1185). In this way, it shall be ensured that the hydrogen produced meets the greenhouse gas (GHG) reduction requirements (For a detailed description of all the provisions, see, for example, H4D Partnership, 2024).

The EU RED and its delegated acts currently do not address hydrogen leakage or its role as an indirect greenhouse gas, despite its potential to significantly exacerbate climate

change (see, for example, Mar et al., 2024). Apart from specific requirements outlined in this chapter, in the EU RED there are no further sustainability criteria for RFNBOs³.

Hydrogen-Specific vs. Generic

While the EU RED was originally designed as a generic framework, establishing overarching rules to promote renewable energy across multiple sectors, it now includes specific provisions for renewable fuels of non-biological origin (RFNBOs), including renewable hydrogen. These provisions define sustainability and greenhouse gas reduction criteria for production and use. Accordingly, the EU RED, together with its delegated acts, can be considered relevant as a hydrogen-specific framework.

Binding vs. Voluntary

The RED III, as a directive, insofar as it has a binding character, as member states are required to transpose it into national law within 18 months, with a deadline set for May 2025. Member States are also responsible for ensuring that the renewable energy consumption targets—outlined in the directive—are met. The sustainability and GHG criteria established in the RED are not a precondition for producing or importing hydrogen into the EU, nor do they directly apply to individual producers. However, they are mandatory if hydrogen or other fuels are to be counted toward the renewable energy targets and obligations defined in EU legislation.

Scope

RED III establishes that, by 2030, 42.5% of energy consumed across all sectors in the EU must be sourced from renewable energy, complemented by additional sector-specific targets for electricity, heating, transport, and fuels. The directive applies to hydrogen consumed within the EU, meaning that imported hydrogen must also comply with its sustainability and greenhouse gas reduction requirements in order to be recognized toward EU or national renewable energy targets. This ensures that both domestic production and imports contribute to the EU's renewable energy and climate objectives, effectively extending the directive's regulatory reach along the full hydrogen value chain.

The EU Hydrogen and Gas Decarbonisation Package

While the EU prioritizes electrolytic hydrogen produced from renewable energy sources (renewable hydrogen), as reflected in various regulatory documents and the overall strategy, the use of low-carbon hydrogen—hydrogen produced from non-renewable sources that still accounts for significant GHG emission savings—is acknowledged as a transitional solution for the ramp-up of the renewable hydrogen market and thus may play role in the energy transition, “particularly in the short and medium term” (Recital 13 of Directive (EU) 2024/1788)⁴. To implement this approach in practice, the EU has established a comprehensive legislative and regulatory framework that governs both renewable and low-carbon hydrogen.

The hydrogen and gas decarbonisation package provides a unified governance framework covering both renewable hydrogen (RFNBO-H₂) and low-carbon hydrogen. It comprises Directive (EU) 2024/1788 (Hydrogen and Gas Market Directive), Regulation (EU) 2024/1789, and Commission Delegated Regulation (EU) 2025/2359, setting out consistent rules for production, reporting, and certification. Within this framework, producers may rely on third-party certification systems, similar to those recognized under the RED, typically via voluntary certification schemes. As per the publication of this study, the European Commission has not yet published which voluntary schemes will be recognized.

Sustainability Dimensions Covered

The package addresses hydrogen primarily from a climate perspective. Article 2(11) of Directive (EU) 2024/1788 defines low-carbon hydrogen as hydrogen “derived from non-renewable sources, which meets the greenhouse gas emission reduction threshold of 70%

³ EU RED sets out some broader sustainability criteria under Articles 29, 29a, and 30 – but only for bioenergy. These sustainability requirements, such as restrictions on feedstock sourced from land with high biodiversity value (e.g., primary or non-degraded species-rich forests) or high carbon stock (e.g., wetlands), apply only to biofuels, bioliquids, and biomass fuels (Article 29). Article 29a specifies the greenhouse gas (GHG) emission savings requirements for renewable fuels of non-biological origin (RFNBOs), while Article 30 sets out the verification and compliance mechanisms applicable to both RFNBOs and bioenergy. EU Directive 2024/1788/EC, part of the hydrogen and gas decarbonization package, states in Article 9 that “renewable gas” must be certified in accordance with RED Articles 29, 29a, and 30. The directive does not differentiate between these articles in terms of scope. Thus, RFNBOs, including hydrogen, are only subject to Articles 29a and 30—requiring 70% GHG savings and compliance with additionality and correlation rules, but not the broader sustainability criteria in Article 29. For details, see the RIFS study developed by Mauger (2025).

⁴ Note that the EU did not set EU-wide quantitative targets for low-carbon hydrogen production and imports

compared to the fossil fuel comparator for renewable fuels of non-biological origin” (set at 94 gCO₂e/MJ, see above). In this way, it applies the same greenhouse gas intensity threshold as in the EU RED. The delegated act (CDR EU) 2025/2359, published in November 2025, specifies the rules and allows several production routes to qualify as low-carbon, following a well-to-wheel lifecycle approach. Importantly, similar methodologies and thresholds also apply to RFNBO-hydrogen under the RED framework, ensuring that both types of hydrogen are subject to comparable sustainability criteria where relevant.

Eligible pathways include:

- Electrolytic hydrogen using electricity that is not fully renewable, with GHG emissions calculated using one of four methods (Annex A, pt. 6 of the delegated act 2025/2359): the annual average grid emissions, the hourly day-ahead forecast, a method based on full-load hours where electricity is considered “clean” if the plant runs only during hours when renewables or nuclear set the electricity price in the previous year and assigned a high fixed value otherwise, or the hourly emissions of the marginal power plant.
- Fossil-based hydrogen with carbon capture, where CO₂ is permanently stored (CCS) or chemically bound in long-lived products (CCU) (Annex A, pts. 17–18, CDR (EU) 2025/2359).
- Hybrid processes combining renewable fuels, low-carbon fuels, and conventional fossil inputs, with emissions allocated proportionally based on the energy content of the inputs (Annex A, pts. 1 and 3, CDR (EU) 2025/2359). These allocation principles align with the RED rules for RFNBO-H₂ when co-processing with conventional fuels.

By July 2028, the Commission shall assess the potential of considering nuclear-based electricity as an eligible option, too (Article 3, *ibid.*).

Similar to the RED, the gas package does not address hydrogen leakage or its role as an indirect greenhouse gas. Although the Hydrogen and Gas Market Directive within the package refers to hydrogen emissions, there is no requirement to account for such emissions along the value chain. The omission in the directive may be justified by the current lack of scientific consensus and precise data on hydrogen’s global warming potential. However, the directive notes that hydrogen emissions will be incorporated once robust scientific evidence becomes available (Mar et al., 2024).

Generally, as outlined in the directive (Recital 13 - Directive EU 2024/1788), emission thresholds for low-carbon hydrogen - set at a 70% reduction - “should become” stricter for low-carbon production facilities that commence operations from January 1, 2031, due to expected technological advancements and to stimulate these. For that purpose and also to revise certification procedures, the directive is set for a potential revision by December 31, 2030 (Article 92). Besides that, the Gas Directive also states that member states shall not go into long-term contracts with (unabated) fossil gas extending beyond the year of 2049 (Recital 144 and Article 31, Directive EU 2024/1788).

Hydrogen-Specific vs. Generic

While the EU hydrogen and decarbonisation gas market package builds upon existing gas market legislation, it introduces specific provisions tailored to hydrogen and other low-carbon gases. The package defines low-carbon hydrogen and harmonizes its requirements with the RED, providing a clear regulatory framework for hydrogen production, transport, and consumption. This targeted approach positions the package as a hydrogen-specific framework within the broader context of EU energy legislation.

Binding vs. Voluntary

Directive (EU) 2024/1788 mandates EU Member States to transpose the rules into national law by mid-2026, ensuring uniform implementation across the EU. As with the RED, the regulatory framework for low-carbon hydrogen in the EU only becomes binding when the term “low-carbon hydrogen” is explicitly used—for example, in the context of cross-border trade or when hydrogen is to be classified and marketed as such.

Scope

The EU hydrogen and decarbonised gas market package applies to the hydrogen and gas value chain within the EU, covering production, transport, storage, and consumption. This approach ensures that both domestic production and imports contribute to the EU’s decarbonization objectives while maintaining consistent standards across the hydrogen value chain, for both renewable and low-carbon hydrogen. Beyond low-carbon hydrogen, other

gaseous or liquid fuels can also qualify as low-carbon, such as ammonia, methanol, and e-fuels produced from low-carbon hydrogen or syngas, while excluding biofuels and recycled carbon fuels derived from non-renewable waste.

EU Emission Trading System (EU ETS)

The EU Emissions Trading System (EU ETS) was established under Directive 2003/87/EC, launching the first EU-wide cap-and-trade system for CO₂ emissions in 2005. It initially covered power and heat generation as well as energy-intensive industries, with a relatively generous allocation of free allowances, which led to significant price volatility (LIFE ETX, 2024).

Recent reforms, established as the EU ETS 2 under Directive (EU) 2023/959, modernize and expand the EU Emissions Trading System. The revised framework extends coverage to additional sectors, including buildings, transport, and hydrogen production (see details below), and introduces more stringent requirements for monitoring, reporting, and verification (MRV), alongside more ambitious emission reduction targets.

From 1 January 2025, operators in affected sectors must hold a GHG emissions permit and an approved monitoring plan detailing methodologies for emissions tracking and reporting. Annual emissions reports are due by 30 April, and from 2026 must be verified by accredited verifiers under the Monitoring and Reporting Regulation (MRR, EU 2018/2066) and the Accreditation and Verification Regulation (AVR, EU 2018/2067). Verifiers are accredited by National Accreditation Bodies, while national authorities oversee enforcement (EC, n.d.-c).

Operators of covered sectors are required to surrender allowances equal to their verified annual emissions. These allowances can be purchased through auctions or traded on secondary markets, allowing entities flexibility in meeting compliance obligations.

Sustainability Dimension Covered

The EU ETS requires covered sectors to monitor and report their direct GHG emissions and surrender a corresponding number of allowances (Scholz et al., 2025). By pricing carbon, the EU ETS incentivizes lower-emission alternatives, including hydrogen-based and synthetic fuels, without addressing broader environmental or social sustainability dimensions.

Hydrogen-Specific vs. Generic

The EU ETS is broadly applicable across sectors, including power generation, industry, and aviation. It refers explicitly to hydrogen production exceeding five tonnes per day and indirectly influences hydrogen production via the carbon price applied to fossil-fuel-based energy, thus incentivizing renewable and low-carbon hydrogen-based technologies.

Binding vs. Voluntary

The EU ETS is legally binding for all covered entities and sectors. Non-compliance with emission reduction obligations triggers financial penalties (€100 per excess tonne of CO₂e, adjusted for inflation) and public disclosure of the defaulting operators (EC, n.d.-f).

Scope

The EU ETS covers large power plants, combined heat and power (CHP) installations, and energy-intensive industries such as steel, cement, aluminum, and chemicals (DEHSt, 2024). Its scope has expanded to include aviation (from 2012), maritime transport (from 2024), and from 2026 certain hydrogen production facilities – for those located in the EU and EEA that generate more than five tonnes of hydrogen per day (regardless of the feedstock, see Annex 1 of EC Directive 2023/959).

EU Carbon Border Adjustment Mechanism (CBAM)

The EU CBAM (Regulation (EU) 2023/956 and its amended revision Regulation (EU) 2025/2083) assigns an additional carbon-related cost to imported goods, aligned with the weekly price of equivalent emission allowances of the same good under the EU ETS. This ensures that the cost of carbon for imported goods and domestically produced goods within the EU remains the same, aiming to prevent carbon leakage (International PtX Hub, 2023; Parkes, 2024). It is organized in two phases:

- **Transitional Phase (2023–2025):** Importers report emissions but are not required to purchase CBAM certificates.
- **Definitive Phase (from 2026):** From 1 January 2026, importers must calculate and report 100% of the embedded emissions of CBAM goods. However, the obligation to surrender CBAM certificates is phased in gradually, reflecting the progressive phase-out of free EU ETS allowances. As a result, certificates must be surrendered for 2.5% of embedded emissions in 2026, increasing to 51.5% by 2030 and reaching 100% by 2034 (International PtX Hub, 2023).

Sustainability Dimensions Covered

The EU Carbon Border Adjustment Mechanism (CBAM) focuses exclusively on greenhouse gas (GHG) emissions, similar to the EU ETS. CBAM treats emissions associated with covered goods, including hydrogen and certain derivatives, differently, particularly with regard to direct, indirect, and upstream emissions from precursor materials.

Definitions: Direct emissions refer to emissions that result “from the production process, expressed in tonnes of CO₂e, from fuel use directly or indirectly linked to the hydrogen production process and from flue gas cleaning.” Indirect emissions are defined as emissions “resulting from the production of electricity consumed in the production processes of goods, expressed in tonnes of CO₂e, within the system boundaries referred to in the implementing act adopted pursuant to Article 7(7)” (Annex IV of Regulation EU 2023/956).

Hydrogen: In the definitive phase of CBAM, starting from January 1, 2026, only direct emissions are considered for hydrogen (Annex II, Regulation EU 2023/956). For electrolytic hydrogen, these provisions mean that no emissions from electricity generation (indirect emissions) must be taken into account. Consequently, there is no differentiation between grid-based hydrogen and hydrogen produced using exclusively renewable electricity.⁵ For this, the electricity-related emissions for hydrogen that meets the European Commission’s definition of an RFNBO were considered zero (Annex II, 3.6.2.2 of CIR (EU) 2023/1773).

The reason that hydrogen, along with a range of other sectors, are only subject to CBAM charges for direct emissions is that EU producers in these sectors may receive indirect cost compensation for electricity-related CO₂ costs (Recital 19, Regulation EU 2023/956; EC, 2025a, p. 47). This way importers are not charged for indirect emissions, for which domestic producers may receive compensation (EC, 2025a, p. 47-48). The Commission has indicated that this approach could be reconsidered in future CBAM revisions, and in December 2025, it clarified that the issue may be addressed in a potential CBAM revision in 2027 (ibid, p. 49). Transport-related emissions and upstream emissions from precursor materials used in hydrogen production are excluded in both phases. As a result, GHG-intensive process steps such as feedstock sourcing, production, and processing are not accounted for (Annex II, 3.6.2.2 of CIR (EU) 2023/1773). A report published by the Commission in December 2025 noted that many transport-related emissions are, or will be, covered under the EU ETS through other emission types, including emissions from air, maritime, and road transport (EC, 2025a, p. 51).

Ammonia: For hydrogen as the feedstock for ammonia, two specific production routes are specified: SMR of natural gas or biogas, and gasification of coal or other fuels (Annex II, 3.7.2, CIR 2023 (EU) 1773). Hydrogen produced through other routes is also being considered and is treated as a precursor material (including its embedded emissions) (ibid.). For all ammonia production routes, indirect emissions, including those from electrolytic hydrogen as a feedstock, must also be accounted for (as ammonia is not listed in Annex II of Regulation (EU) 2023/956). Consequently, GHG emissions from electricity used for the electrolysis of hydrogen must be taken into account.

Mixed Fertilizers: Both direct and indirect emissions arising during the production process are considered, including their own indirect (embedded) emissions from precursors such as ammonia, urea, or nitric acid, if used (Annex 3.10.2 of CIR (EU) 2023/1773; Point 5.5.3.4 of CBAM Guidance Document EC, 2024c).

Generally, if importers can demonstrate that a carbon price was already paid during the production of the imported goods, the equivalent amount may be deducted (EC, n.d.-b). Table 1 summarizes the emissions exposures and obligations relevant for imports of hydrogen and its derivatives under CBAM.

⁵ This contrasts with the transitional phase, during which indirect emissions were required to be reported (as in Annex III, D.4 of CIR (EU) 2023/1773).

TABLE 1: GHG EMISSION EXPOSURE OF DIFFERENT H₂ PRODUCTION PATHWAYS AND DERIVATIVES UNDER EU CBAM

Hydrogen Production Pathways		Definite Phase (from 2026): Covered Emissions	Implications
Electrolytic Hydrogen (Water Electrolysis)	Renewable Energy Sources	Only Direct Emissions Covered. No Precursor Emissions.	Low GHG Emission Exposure
	Grid Electricity/ Non-Renewable Source	Only Direct Emissions Covered. No Precursor Emissions.	Low GHG Emission Exposure
Hydrogen Based on Natural Gas	With CCU/CCS (Blue H ₂)	Only Direct Emissions Covered. No Precursor Emissions.	Medium GHG Emission Exposure
	Without CCU/CCS (Grey H ₂)	Only Direct Emissions Covered. No Precursor Emissions.	High GHG Emission Exposure
Ammonia	Depending on H ₂ Production Pathway	Direct and Indirect Emissions Covered. Precursor Emissions Included.	GHG Emission Exposure Depending on H ₂ Production Pathway
Fertilizer	Depending on H ₂ Production Pathway	Direct and Indirect Emissions Covered. Precursor Emissions Included.	GHG Emission Exposure Depending on the Ammonia and H ₂ Production Pathway

Source: Authors, based on International PtX Hub (2023), Directive (EU) 2023/959, Regulation (EU) 2023/956, CDR (EU) 2023/1773 & CDR (EU) 2024/873

Hydrogen-Specific vs. Generic

Although a generic instrument, CBAM explicitly covers hydrogen and hydrogen-derived products such as steel, ammonia, and fertilizers. It provides hydrogen-specific provisions and incentives while also indirectly promoting the use of renewable and low-carbon hydrogen.

Binding vs. Voluntary

CBAM is legally binding for covered sectors and imports. Under the revised CBAM framework, companies are required to calculate and report 100% of the embedded emissions in imported CBAM goods. However, during the year, they are only required to hold CBAM certificates covering at least 50% of the emissions associated with goods imported year-to-date (reduced from the previous 80% requirement). The remaining certificates do not need to be held immediately but must be purchased and surrendered in full by 30 September of the following year, when the annual CBAM declaration is due. This change primarily reduces short-term liquidity and compliance pressure, while maintaining full emissions coverage over the annual compliance cycle. Although CBAM certificates will only be purchased from 2027 onwards, the CBAM obligation economically applies to imports from 1 January 2026 (DEHSt, n.d.).

An authorized CBAM declarant who does not submit the required certificates by 30 September for emissions from the previous year's imports will be subject to a penalty. The penalty is the same as the EU ETS excess emissions charge for the year of import and applies to each certificate that has not been surrendered (Article 26-1 of Regulation (EU) 2025/2083).

Scope

The EU Carbon Border Adjustment Mechanism (CBAM) complements the EU Emissions Trading System (EU ETS): while the EU ETS regulates domestic production, CBAM applies to imports. The regulation covers hydrogen, hydrogen-derived products, and selected other goods. In October 2025, an amendment to CBAM entered into force (Regulation (EU) 2025/2083), aimed at simplifying procedures and reducing regulatory and administrative burdens, particularly for small and medium-sized enterprises. As part of this revision, a 'de minimis' threshold was introduced, under which imports not exceeding 50 tonnes of net mass per calendar year are exempt from CBAM obligations (EC, 2025d). Hydrogen – unlike other hydrogen-derived goods – is excluded from this, meaning that CBAM applies to imported hydrogen from the first tonne onward (Article 2a(4), Regulation (EU) 2025/2083).

EU EIA Directive (DIRECTIVE 2014/52/EU)

Directive 2014/52/EU (amending Directive 2011/92/EU), commonly referred to as the Environmental Impact Assessment (EIA) Directive, requires EU Member States to ensure that certain public and private projects undergo an Environmental Impact Assessment (EIA) prior to receiving development consent, where such projects are likely to have significant environmental effects.

As part of the EIA process, the different potential impacts must be evaluated with respect to their spatial extent, nature, intensity, and complexity; the probability and reversibility of the effects; their cumulative impact with other projects; and the potential for effective mitigation (Annex III, 2 of Directive 2014/52/EU). The precise scope of the assessment may be determined by the relevant authorities (e.g., environmental authorities) and may be requested by project developers (Recital 30, *ibid.*). Additionally, an EIA report must be developed, which must be evaluated by competent authorities, and where the public must have the opportunity to comment and to raise concerns. This report must assess the project's likely significant environmental effects (direct, indirect, short- and long-term), outline mitigation measures, and compare reasonable alternatives, including the option of not proceeding. The report must be made publicly available for at least 30 days to allow affected or interested parties to submit comments. This should be done through appropriate means such as electronic publication, public notices, and local newspapers.

Under Article 8, public consultation process results “shall be duly taken into account” in the decision-making process. Consequently, competent authorities are required to substantively evaluate all input received. The final EIA report must be submitted to the competent authority for review. As per Article 11, decisions, e.g., environmental permits, may be challenged in court by affected individuals or groups.

Sustainability Dimensions Covered

The purpose of the EIA process is to identify, describe, and assess the direct and indirect significant impacts of a project on various environmental factors, including population and human health; biodiversity (particularly protected species and habitats, with reference to relevant EU directives) land, soil, water, air, and climate, material assets, and cultural heritage (Article 3, *ibid.*).

Hydrogen-Specific vs. Generic

The EU Environmental Impact Assessment (EIA) Directive constitutes a generic framework, providing overarching approaches to identify, manage, and mitigate environmental and social risks. It does not include any provisions, guidelines, or measures specifically tailored to hydrogen projects.

Binding vs. Voluntary

The EIA Directive itself outlines which projects are subject to an EIA, as specified in Annexes I and II. While some projects require only preliminary screening, the European Commission has clarified that industrial-scale hydrogen production at integrated chemical facilities within the EU must undergo a full EIA process (EC, 2011, Article 4.1; EC, 2024a). While the Directive does not explicitly define 'industrial scale,' the European Commission's DG Environment has indicated that 'industrial scale' may “vary from a few grams (of a highly specialized product), to many tonnes (of a bulk chemical product)” (DG Environment, 2019, IED Annex I.9), but also clarified that if it is intended for commercial purposes that this would typically be considered as an indicator for that.

Scope

The EU EIA Directive formally applies only to projects within EU Member States and is also referred to by the European Investment Bank (EIB) in its project financing. Specifically, projects likely to have significant effects on the environment, human health, or well-being must undergo an environmental assessment in line with the EIA Directive for all projects within the EU and EFTA countries. For projects outside the EU, an EIA in accordance with the directive is required if the project falls under Annex I, such as hydrogen production projects, or if mandated by national legislation (EIB, 2022, p. 2 - 4). Box 1 highlights the significance of the directive by illustrating its reference in several other pieces of EU legislation. For simplifying environmental assessments and permitting, the EIA Directive will likely also undergo a revision process, see Box 2 on page 38.

Box 1: The Role of the EU EIA Directive in Other EU Legislation

The EIA Directive is referenced in various other EU legislative instruments, though often in a limited or indicative capacity rather than as a binding requirement.

Within the EU Taxonomy Regulation, the EIA Directive is cited as a mandatory reference to demonstrate that an activity causes no significant harm to the objective of protecting and restoring biodiversity and ecosystems. It is also mentioned as a possible means to demonstrate compliance with the "no significant harm" criterion for the sustainable use and protection of water and marine resources.

The European Sustainability Reporting Standards (ESRS), which operationalize the Corporate Sustainability Reporting Directive (CSRD), also refer to the EIA Directive—specifically in relation to the identification and disclosure of biodiversity-related risks and impacts. However, the EIA is not mandated as a tool for identifying such risks; rather, companies are required to report in alignment with the ESRS definitions of biodiversity risks and adverse impacts.

RED III references the EIA Directive only with regard to the characteristics of the directive itself, and without establishing it as a prerequisite for demonstrating compliance with the requirements for Renewable Fuels of Non-Biological Origin (RFNBOs). A similar pattern applies to the Delegated Regulation (EU) 2022/1288 under the Sustainable Finance Disclosure Regulation (SFDR) in the context of potential biodiversity risks.

In other legislative frameworks discussed in this study—namely the Corporate Sustainability Due Diligence Directive (CSDDD), the EU Emissions Trading System (EU ETS), and the Carbon Border Adjustment Mechanism (CBAM)—there is no legal requirement or expectation to conduct an environmental impact assessment under the EIA Directive.

EU Industrial Emission Directive (IED, Directive EU 2024/1785)

The EU Industrial Emissions Directive (IED – Directive (EU) 2024/1785) stipulates that operators falling within its scope must obtain an integrated environmental permit based on the application of 'Best Available Techniques' (BAT). Unlike the EU EIA Directive, the IED does not prescribe a standardized content structure for permits, giving national competent authorities greater flexibility. However, similar to the EIA Directive, the IED mandates public consultation, ensuring stakeholder involvement in the permitting process.

Sustainability Dimensions Covered

The EU Industrial Emissions Directive aims to prevent and reduce pollution from industrial activities by regulating emissions to air, water, and land, as well as addressing waste generation, energy efficiency, and accident prevention. It covers pollutants such as NO_x, SO_x, CO₂, liquid discharges, solid waste, heat, noise, and vibrations. The IED will likely undergo a revision process, potentially allowing exemptions for certain industrial facilities, see Box 2.

Hydrogen-Specific vs. Generic

The EU Industrial Emissions Directive, like the EU EIA Directive, provides general provisions for identifying, managing, and mitigating environmental impacts. It is not hydrogen-specific and does not include tailored regulations, guidelines, or instruments for hydrogen production or its associated processes.

Binding vs. Voluntary

The EU Industrial Emissions Directive (IED) is legally binding for all installations and operators covered under its scope. Member States are required to transpose their provisions into national law and ensure compliance through permitting, monitoring, and enforcement mechanisms. Failure to comply with emission limit values or other regulatory requirements can result in administrative sanctions, fines, or suspension of operations, depending on national implementation.

Scope

The directive applies to various industrial installations, such as power plants, chemical facilities, waste management sites, and large-scale livestock operations. Notably, Annex I specifically includes the electrolysis of water for hydrogen production where the output exceeds 50 tonnes per day (Point 6.6, Annex I, DIRECTIVE (EU) 2024/1785). For other

hydrogen production pathways, the IED is generally applicable from the first tonne of production (Point 4.2(a), *ibid.*).

Box 2: The Environmental Omnibus Proposal by the EC (December 2025)

In December 2025, the European Commission published the Environmental Omnibus Proposal, which aims to simplify and streamline various environmental regulations in areas such as industrial emissions, circular economy, environmental assessments, and geospatial data. Renewable energy is considered a strategic sector. The package addresses multiple legislative instruments. For hydrogen, the most pertinent elements relate to:

- Simplified and accelerated environmental assessments and permitting, including provisions under the EU Environmental Impact Assessment (EIA) Directive, and
- Industrial emissions, in particular, amendments to the Industrial Emissions Directive (IED).

Environmental Assessments

The proposal (see EC, 2025h) aims to make environmental permitting procedures faster and more coherent. Project developers would benefit from streamlined and accelerated permitting processes coordinated via a single point of contact, enhanced co-operation between authorities for assessments with cross-border impacts, greater use of digital tools, adequate staffing and capacity at permitting authorities, and limited financial support to cover administrative costs (EC, 2025f).

IED Revisions

To support the transition to clean energy and low-carbon technologies, the proposal (see EC, 2025f) addresses hydrogen-based industrial processes. While hydrogen combustion does not produce CO₂, higher hydrogen content in fuels would increase NO_x emissions during combustion. Current IED and Medium Combustion Plant Directive (MCPD) limits would not fully account for this effect, which stakeholders have identified as a potential barrier to hydrogen deployment. The proposal, therefore, suggests a specific exemption from certain NO_x emission limits for combustion plants that would co-fire gas with more than 20% hydrogen by volume (EC, 2025f, p. 5).

The Commission emphasizes that, aside from these targeted amendments, other provisions of these environmental regulations would not be modified (EC, 2025e, p. 5). The proposal will undergo review, negotiation, and adoption by the European Parliament and the Council of the EU. Following adoption, the affected directives and regulations will be formally amended and implemented at the EU and national level.

EU Corporate Sustainability Due Diligence Directive (CSDDD)

The EU Corporate Sustainability Due Diligence Directive (CSDDD; Directive (EU) 2024/1760, amended by Directive (EU) 2026/470) is a centerpiece of European sustainability legislation. The CSDDD establishes the obligation to identify, prevent, and mitigate adverse impacts on human rights and the environment, including climate-related concerns, for certain large companies conducting business in the EU (see details below). The directive originally entered into force on 25 July 2024, requiring EU Member States to transpose its provisions into national law by 26 July 2026 (Bueno et al., 2024; Directive (EU) 2024/1760). During 2025, as part of the Omnibus I process, the directive underwent a comprehensive revision (Directive (EU), 2026/470). Member States must transpose the CSDDD by 26 July 2028, with compliance required for the 2028 financial year (Article 5, Directive (EU) 2026/470).

The revised CSDDD requires companies to evaluate a number of sustainability requirements as part of a scoping exercise (see dimensions covered below). For this, companies rely on information reasonably available to them. Based on the scoping results, in-depth assessments are carried out in high-risk areas to determine the nature, severity, and likelihood of adverse impacts, guiding prioritization and the adoption of appropriate measures (Article 8(2), Directive (EU) 2026/470). The risk-based approach is intended to ensure that adverse impacts are addressed proportionately across the value chain while reducing unnecessary administrative burdens (see, for example, Van den Berghe et al., 2024).

Sustainability Dimension Covered (1) - Social and Human Rights Aspects

Companies under the CSDDD must identify and safeguard the rights of individuals, groups, and communities to land and resources. They are prohibited from engaging in activities that could deprive people of their means of subsistence (as outlined, for example, in Annex Part I, Point 16 of Directive (EU) 2024/1760). The CSDDD refers to obligations of other international frameworks, such as the International Covenant on Civil and Political Rights

(ICCPR) and the International Covenant on Economic, Social, and Cultural Rights (ICESCR). In other words, the directive protects individuals and communities from land dispossession and ensures that companies respect legal land rights. The practice of land grabbing, where companies unlawfully acquire land, forests, and waters, is explicitly addressed (As described above in Point 16, see Van den Berghe et al., 2024, p. 46).

Additionally, companies are required to adhere to additional human rights standards, particularly in contexts involving marginalized groups. This includes recognizing intersecting factors such as gender, age, race, ethnicity, class, caste, education, migration status, disability, and socio-economic status. The UN Declaration on the Rights of Indigenous Peoples and its principle of Free, Prior, and Informed Consent are particularly relevant, as well as other related international treaties (Recital 33 of Directive (EU) 2024/1760). Additional obligations extend to safeguarding fundamental human rights such as the right to food, safe drinking water and sanitation, health, safety, property, and a healthy environment. Environmental concerns and social rights are interconnected, as environmental degradation should not undermine fundamental rights, such as access to food and clean water. Affected companies must also minimize negative impacts on natural heritage sites designated under the World Cultural and Natural Heritage framework (Van den Berghe et al., 2024).

Sustainability Dimension Covered (2) - Environmental

While CSDDD is primarily a human rights-focused framework, it also obliges affected companies to identify and ensure that their activities do not cause measurable environmental degradation. This includes soil, such as harmful soil change and land degradation, water or air pollution, harmful emissions, excessive water consumption, or other impacts on natural resources, such as deforestation. Business activities must also avoid significantly and adversely affecting ecosystem services (Recital 32 and Annex I, Part I (15), Directive (EU) 2024/1760). The directive provides criteria for assessing the severity of environmental harm, distinguishing between short-term, medium-term, and long-term impacts, as well as the extent of damage and its reversibility (Article 3.1b and Annexes of Directive (EU) 2024/1760). Additionally, companies are required to implement measures to prevent or minimize adverse impacts on biodiversity, in accordance with Article 10(b) of the 1992 Convention on Biological Diversity (Annex 2, part II). The referenced article of the convention provides broad guidance, stating that entities should, "as far as possible and as appropriate," adopt measures concerning the use of biological resources to avoid or mitigate negative effects on biodiversity (Secretariat of the Convention on Biological Diversity, 2011). Further obligations under the CSDDD include avoiding and minimizing negative impacts on wetlands, preventing pollution from ships, and prohibiting the unlawful use of ozone-depleting substances and specific hazardous chemicals, such as persistent organic pollutants, aligning with other international agreements (Annex, Part 1, Section 1, Points 15 and 16, Directive (EU) 2024/1760).

Hydrogen-Specific vs. Generic

The CSDDD constitutes a generic framework for managing human rights and environmental risks and does not contain hydrogen-specific provisions. However, under Article 19 of the Directive, the European Commission is to publish sector-specific guidelines, among other things, "to provide support to companies or to Member State authorities on how companies should fulfil their due diligence obligations" (Point 1), in consultation with various international stakeholders having due diligence expertise. Such guidelines shall also include sector-specific guidance (Article 19(2c)).

Binding vs. Voluntary

The EU CSDDD imposes legally binding obligations on certain companies operating in the EU—including non-EU companies with significant EU operations—to identify, manage, and mitigate sustainability-related risks, and to report on these activities. Following the CSDDD revision, companies with ≥5,000 employees and ≥€1.5 billion in turnover are required to comply with the CSDDD. For non-EU companies, the directive applies if EU turnover exceeds €1.5 billion, with no employee threshold (Reed Smith, 2025). To ensure compliance, each Member State should designate a national authority to monitor adherence and investigate violations. Non-compliance carries financial penalties, to be set by each Member State and capped at 3% of the net worldwide turnover of the company. Stakeholders—including individuals, trade unions, civil society, and environmental organizations—can submit complaints, and companies must periodically monitor and document their supply chains (Reed Smith, 2025). Regarding hydrogen, the CSDDD may be relevant for actors at various points of the value chain, including certain purchasers, intermediaries, and

producers. A detailed assessment of the directive's implications for hydrogen sustainability will be published in a forthcoming RIFS study.

Scope

Companies subject to the CSDDD are required to conduct due diligence and report on activities across their entire value chain. Under the revised directive, companies apply a risk-based due diligence approach, focusing on areas where adverse impacts are most likely or severe and requesting only information that is reasonably necessary within their own operations, their subsidiaries, and, where relevant, their business partners (Directive (EU) 2026/470 of the European Parliament and of the Council of 26 February Amending Directives 2006/43/EC, 2013/34/EU, (EU) 2022/2464 and (EU) 2024/1760 as Regards Certain Corporate Sustainability Reporting Requirements and Certain Corporate Sustainability Due Diligence Requirements, 2026).

3.3 Transparency and Disclosure Mechanisms

Key Highlights for Hydrogen Sustainability

EU Taxonomy

- Provides a classification system for environmentally sustainable economic if they contribute to one or several specific environmental objectives, and safeguard the environment and social concerns.
- Hydrogen-related activities under the EU Taxonomy include the production, storage, and distribution of hydrogen, as well as the manufacture of equipment for its production and use.
- For example, hydrogen production to be classified, it must substantially contribute to the environmental objective of climate change mitigation (or climate change adaptation), by maintaining emissions below a GHG intensity threshold of 3 kg CO₂e per kg H₂.
- Additionally, activities must comply with Do No Significant Harm (DNSH) criteria covering climate adaptation, water and marine resource protection, pollution control, and biodiversity/ecosystem protection (incl. specific provisions)
- Minimum social safeguards must be respected, aligned with high-level principles like the OECD Guidelines for Multinational Enterprises, the UN Guiding Principles on Business and Human Rights, and others.
- Actors in scope of the EU CSRD and SFDR must report the extent to which their activities are Taxonomy-eligible and Taxonomy-aligned.

EU Corporate Sustainability Reporting Directive (CSRD)

- Requires certain large companies (from the EU or with a certain turnover in the EU) to disclose sustainability-related information regarding their activities.
- Covers a broad range of environmental, social, human rights, and governance topics, applying a double materiality perspective.
- Provides a generic reporting framework relevant across the hydrogen value chain, combining hydrogen-specific and general provisions. The CSRD is operationalized through the European Sustainability Reporting Standards (ESRS).

European Sustainability Reporting Standards (ESRS)

- The ESRS are the translation of the requirements of the EU CSRD into detailed, operational reporting standards, enabling companies to disclose ESG impacts consistently and comparably.
- Include general standards, topical standards (five Environment, four Social, one Governance), and sector-specific standards (in development).

EU Sustainable Finance Disclosure Regulation (SFDR)

- Requires financial market participants to disclose ESG-related information, applying the double materiality principle by covering both financial risks from sustainability factors and impacts on environmental, social, and governance outcomes.
- Relevant for hydrogen, given the significant capital flows into the sector, including hydrogen-specific investment funds that are required to report under SFDR.

EU Taxonomy

The EU Taxonomy for sustainable activities – consisting of Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment and various delegated acts – is a framework governed by the European Commission. Companies and financial institutions affected by it must disclose the extent to which their activities align with the taxonomy, with Member States supervising compliance. While it does not mandate operational changes, it ensures transparency and comparability of sustainability performance. Through the EU Taxonomy, the European Commission aims to encourage a shift towards more sustainable business practices and contribute to the EU's climate and environmental objectives. While investors remain free to choose where to allocate capital, the Taxonomy shall serve as a tool to guide investment towards activities that support long-term sustainability goals (EC, n.d.-d).

Sustainability Dimensions Covered (1) - Overview

The EU Taxonomy is a framework that enables companies and investors to identify environmentally sustainable economic activities, supporting informed and responsible investment decisions. The legislative package of the taxonomy – consisting of Regulation (EU) 2020/852 and various delegated acts (see below for information about these) – establishes clear criteria for defining what qualifies as an environmentally sustainable activity: An economic activity qualifies as environmentally sustainable if it makes a substantial contribution to at least one of the EU's six environmental objectives while ensuring that it does not cause significant harm to the aspects laid out in the other five objectives⁶, if applicable for the economic activity. Additionally, an economic activity must adhere to minimum social safeguards. The six environmental and climate objectives are:

- Climate Change Mitigation
- Climate Change Adaptation
- Sustainable Use and Protection of Water and Marine Resources
- Transition to a Circular Economy
- Pollution Prevention and Control
- Protection and Restoration of Biodiversity and Ecosystems

Hydrogen-related activities (see 'Scope' Section below) may in principle, be recognized as contributions to climate change mitigation or adaptation. Companies must provide evidence of compliance with the technical screening criteria set out in the relevant EU Taxonomy Delegated Acts, in this case, the Delegated Regulation (EU) 2021/2139 on climate-related activities. These criteria define when an activity qualifies as making a substantial contribution while ensuring it does no significant harm (DNSH).

Sustainability Dimensions Covered (2) - Substantial Contribution of Hydrogen Production towards Climate Change Mitigation

The delegated act that establishes the screening criteria of the Taxonomy for climate change mitigation (CDR (EU) 2021/2139) specifies that the production of hydrogen and hydrogen-based synthetic fuels can be considered as making a substantial contribution to climate change mitigation if their life-cycle GHG emissions are below 3 kg CO₂e per kg of hydrogen produced. For hydrogen-based synthetic fuels a higher threshold of 3.38 kg CO₂e per kg of hydrogen is applied (Annex I, Section 3.10 of CDR (EU) 2021/2139)⁷. Consequently, not only renewable fuels of non-biological origin (RFNBOs), but in principle any hydrogen production pathway may qualify as environmentally sustainable under the EU Taxonomy, provided that the applicable GHG emission threshold is met and compliance with the minimum social safeguards as well as the 'Do No Significant Harm' (DNSH) criteria is ensured.

For the calculation of life-cycle GHG emissions, the Taxonomy Delegated Act (Annex I, Section 3.10, CDR 2021/2139) allows the use of different methodologies, namely the methodology set out in the EU RED, thus the methodology specified in Commission Delegated Regulation (EU) 2023/1185, as well as the international standards ISO 14067:2018 or ISO

⁶ Additionally, the EU Taxonomy defines transitional activities, applicable only to climate change mitigation, as activities for which no fully low-carbon alternative exists, provided they follow a credible pathway to climate neutrality and avoid long-term lock-in (Article 10-2 Regulation EU 2020/852). Enabling activities, potentially relevant across all environmental objectives, directly support other activities' environmental contributions without undermining long-term goals and deliver a net positive life-cycle impact (Article 16, Regulation EU 2020/852). Neither classification applies to hydrogen.

⁷ Note that the provisions do not classify production pathways or their (potentially differing) emissions as transitional activities. For hydrogen, making a substantial contribution to climate change mitigation depends exclusively on meeting the GHG emission threshold.

14064-1:2018. The delegated act does not establish a legally binding hierarchy between these methodologies, as all approaches are formally permitted under the regulation.

However, the methodological approaches differ with regard to their treatment of system boundaries. While the RED-based methodology follows a clearly defined well-to-wheel life-cycle perspective, the ISO standards allow for greater flexibility in defining system boundaries. In an explanatory note, the European Commission clarifies that, although different methodologies are permissible, preference should be given to the methodologies specified in the delegated acts under the Renewable Energy Directive in order to ensure consistency across EU climate and energy policy frameworks (EC, 2024c, p. 16). This guidance is not legally binding but is relevant for the practical implementation and interpretation of the Taxonomy criteria.

In addition to meeting the GHG emission threshold, hydrogen production activities must comply with the DNSH requirements with respect to the other environmental objectives of the EU Taxonomy (apart from 'Transition to a Circular Economy').

Sustainability Dimensions Covered (3) - DNSH Criteria for Climate Change Adaptation

The delegated act mandates a Climate Risk and Vulnerability Assessment. This assessment must demonstrate that the activity—hydrogen production—does not contribute to an increase in climate-related hazards. Examples of such hazards include soil degradation, saline intrusion, and water stress in water bodies (Appendix A, Regulation CDR (EU) 2021/2139).

Sustainability Dimensions Covered (4) - DNSH Criteria for Sustainable Use and Protection of Water and Marine Resources

The delegated act specifies that risks related to preserving water quality and preventing water stress must be identified and addressed, to ensure good water status and ecological potential (App. B). It also references the EU Water Framework Directive (Directive 2000/60/EC) and mandates the development of a water use and protection management plan. Compliance with DNSH criteria can be demonstrated through an EIA with the EU EIA Directive 2011/92 (see Chapter 3.2), provided that it includes an evaluation of the activity's impact on water bodies. This assessment should involve consultation with relevant stakeholders regarding potentially affected water bodies.

Sustainability Dimensions Covered (5) - DNSH Criteria for Pollution Prevention & Control

Next to CDR 2021/2139, slightly revised criteria for these provisions were subsequently published in an additional delegated act (Annex XII, CDR (EU) 2026/73; EC 2026). These refer to various EU regulatory lists of restricted substances. Examples of prohibited materials utilized for an activity include Persistent Organic Pollutants (POPs) and Ozone-Depleting Substances.

Sustainability Dimensions Covered (6) - DNSH Criteria for the Protection and Restoration of Biodiversity and Ecosystems

Appendix D of the Delegated Act (CDR 2021/2139) defines the criteria for ensuring compliance with the DNSH requirements related to biodiversity and ecosystem protection. For hydrogen production, to meet these requirements, an Environmental Impact Assessment in accordance with the EU EIA Directive must be conducted (Appendix D of the Taxonomy). For hydrogen production projects outside the EU, the environmental assessment must comply with equivalent applicable national laws or international standards similar to an EIA or screening process. Internationally recognized assessment methodologies may be used, such as the IFC Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts. If project sites are located near biodiversity-sensitive areas, including Natura 2000 sites, UNESCO World Heritage Sites, and other Key Biodiversity Areas⁸, an appropriate environmental assessment must be conducted, and necessary mitigation measures must be implemented. This assessment must align with the EU Directive on the Conservation of Wild Birds (Directive 2009/147/EC) and the EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (Directive 92/43/EEC). For hydrogen production in non-EU countries, compliance with equivalent international

⁸ Key Biodiversity Areas, defined by the ICUN (2016), are sites that make a significant contribution to the global persistence of biodiversity. They are geographically defined areas where important species, ecosystems, or biodiversity features—often rare, threatened, or geographically restricted—occur in sufficient proportion to be critical for their long-term survival.

standards is required, such as IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.

Sustainability Dimensions Covered (7) - Adherence to Minimum Social Safeguards

An economic activity under the EU Taxonomy can only be considered environmentally sustainable if it also aligns with the OECD Guidelines for Multinational Enterprises, the UN Guiding Principles on Business and Human Rights, Declaration of the International Labour Organization on Fundamental Principles and Rights at Work, as well as the International Bill of Human Rights (Article 18, EU Taxonomy Regulation (EU) 2020/852). Ensuring compliance with minimum social safeguards is crucial, as they establish the foundation for ethical business conduct, labor rights, and human rights protections within companies engaging in activities classified as sustainable under the EU Taxonomy.

Hydrogen-Specific vs. Generic

The Taxonomy combines hydrogen-specific provisions with general sustainability requirements, enabling both targeted and broad applicability across the hydrogen value chain. Certain criteria, such as the greenhouse gas (GHG) emission intensity threshold, are specific to hydrogen and determine whether hydrogen production qualifies as making a substantial contribution to climate change mitigation. Other criteria apply generic provisions, for example, the requirement to conduct an Environmental Impact Assessment (EIA) to satisfy the Do No Significant Harm (DNSH) criterion for the protection and restoration of biodiversity and ecosystems.

Binding vs. Voluntary

Companies covered by the EU Corporate Sustainability Reporting Directive (CSRD, see below) are required to disclose the extent to which their activities fall under the EU Taxonomy (Taxonomy-eligibility) and comply with the criteria in the delegated acts (Taxonomy-alignment). This applies to large EU companies, certain listed SMEs, and non-EU subsidiaries meeting specific thresholds (Andriiuk, 2024). Reporting includes the share of activities classified as sustainable in terms of revenue, capital expenditures (CapEx), and operating expenditures (OpEx), as well as documentation demonstrating substantial contributions to climate objectives and compliance with the DNSH criteria (CDR (EU) 2021/2178). With the revised delegated act on the technical screening criteria (CDR (EU) 2026/73, amending the delegated act on establishing the screening criteria for climate change mitigation of the EU Taxonomy), published on 8 January 2026 and in force from 29 January 2026, the Commission introduced simplifications to reduce the administrative burden. The amendments establish 10% thresholds for non-financial undertakings: as such, turnover, CapEx, or OpEx below 10% of the relevant KPI do not require detailed assessment, and OpEx can be fully excluded if not considered material for the company (Art. 2). Similar rules apply to financial undertakings, including asset managers and investment firms (Arts. 3–6). Reporting templates have also been simplified. The rules apply retrospectively from 1 January 2026.

Taxonomy reports are subject to an external audit to ensure transparency. Financial products marketed as environmentally sustainable must disclose their Taxonomy alignment under the Sustainable Finance Disclosure Regulation (SFDR, see below) (Siri et al., 2024). For financial undertakings, the 2026/73 amendments also introduce a temporary opt-out: from 1 January 2026 until 31 December 2027, they may choose not to apply the detailed EU Taxonomy reporting rules, provided they include a statement in their management report that no activities are claimed as environmentally sustainable (Art. 1(6), §9). Please see Box 3 for an illustration of how the Taxonomy and SFDR are applied under the current rules.

Scope

The Taxonomy applies to economic activities carried out within the EU, covering companies' entire value chains to the extent necessary for assessing environmental performance. It also affects investments and financial products offered in the EU, including activities outside the EU if they are reported by EU-based entities. This ensures that sustainability assessments consider upstream and downstream impacts while providing a consistent, EU-wide framework for reporting and decision-making. Hydrogen is addressed across multiple activities within the Taxonomy, all of which are subject to the criteria of making a substantial contribution, complying with the DNSH requirements, and adhering to minimum social safeguards. The relevant hydrogen-related activities include (EC, n.d.-d):

- Manufacture of hydrogen, which can be recognized either as a substantial contribution to climate mitigation or to climate adaptation.
- Storage of hydrogen; Transmission and distribution networks for renewable and low-carbon gases
- Manufacture of equipment for the production and use of hydrogen

The examples outlined above regarding specific criteria and sustainability considerations primarily refer to the manufacture of hydrogen.

Box 3: EU SFDR and EU Taxonomy in Practice: Hy24

Hy24 is the first and largest hydrogen-focused private equity asset manager globally, investing across clean hydrogen infrastructure, equipment, and technologies. Established in 2021 as a joint venture between Ardian, one of the world's leading private investment houses, and FiveT Hydrogen, a specialist in hydrogen-focused investments, the firm currently manages over €2 billion in assets. Hy24 has successfully launched two funds: the Clean Hydrogen Infrastructure Fund, which may leverage up to €20 billion in additional investor capital, and the Clean Hydrogen Equipment Fund, which focuses on the full hydrogen equipment supply chain (Hy24 Partners, n.d.). To date, the firm has made eleven investments across the hydrogen value chain. Notable examples include a US\$115 million joint equity investment with GIC in InterContinental Energy, a hydrogen developer, whose portfolio of projects is projected to produce over five million tonnes of green hydrogen in Australia and the Middle East (Hy24 Partners, 2023). The firm also holds investments in various other companies, including Stegra, Elyse Energy, Hy2Gen, H2Mobility Deutschland, Everfuel, Enagás Renewable, HysetCo, StormFisher, Hexagon Purus, and H2Site. Hy24's sustainability approach is closely aligned with the EU SFDR and the EU Taxonomy, ensuring transparency, preventing greenwashing, and maintaining investor confidence. The firm also aligns its investments with the OECD Guidelines for Multinational Enterprises and UN Guiding Principles on Business and Human Rights.

Both funds comply with SFDR Article 9, meaning they exclusively invest in assets with a sustainable objective, classified as Article 9 funds. For example, the Infrastructure Fund's sustainable objective is to contribute to climate change mitigation by financing low-carbon hydrogen projects. Through its Principal Adverse Impact (PAI) statement (combined for both funds), Hy24 reports on the fourteen mandatory PAIs required under SFDR, as well as four voluntarily selected PAIs. These include three relating to social and employee matters, relating to accident prevention policy, the rate of accidents, and the number of days lost to injuries, accidents, fatalities, or illness (PAIs 1 – 3 from Table 2, Annex I, SFDR), and one relating to natural species and protected areas (PAI 14, Table 3, Annex I, SFDR). The voluntary PAIs were chosen based on the material relevance to the infrastructure development sector and the reporting requirements of the fund's Limited Partners (Hy24 Partners, 2025).

Additionally, Hy24 reports for each fund individually against four key climate indicators: greenhouse gas intensity, avoided CO₂ emissions, the share of renewable energy consumed, and the share of renewable energy produced. For example, the Clean Hydrogen Infrastructure Fund reports the average GHG emission intensity per kilogram of hydrogen produced by its investee companies for various projects (in 2024, two companies had started hydrogen production; see Hy24 Partners, 2024). Hy24 also discloses extensive information on each fund regarding additional sustainability-related provisions, relating to the pre-screening process to ensure that investments are exclusively aligned with the sustainable investment objective, engagement with investee companies as part of due diligence, ongoing monitoring, and measures to improve ESG-related aspects throughout the holding period (ibid.).

The EU Taxonomy is used to assess technical criteria and GHG emission thresholds to determine which activities qualify as sustainable. Rather than relying on hydrogen "color" labels, investments are evaluated against Taxonomy GHG thresholds, with emissions tracked across each project's lifecycle to avoid distortions from early-stage emissions or office electricity use. In 2024, 86% of investments in the Clean Hydrogen Infrastructure Fund were Taxonomy-aligned based on capital expenditures (97% of eligible CapEx). The remaining 3% of eligible CapEx were not aligned because one portfolio company narrowly exceeded the taxonomy threshold for hydrogen production, while still significantly reducing CO₂ emissions when compared to the conventional method of hydrogen production. The remaining 14% of non-Taxonomy-aligned activities reflects other capital expenditures not covered by the Taxonomy, such as office furniture and office electricity. Neither of the two existing funds invests in companies producing hydrogen from natural gas, including those using carbon capture or storage technologies.

For the disclosures, Hy24 uses the templates provided in the annexes of the SFDR and prepares an additional voluntary report for its investors to present sustainability outcomes.

Corporate Sustainability Reporting Directive (CSRD)

The Corporate Sustainability Reporting Directive (Directive (EU) 2022/2464, amended by Directive (EU) 2026/470) establishes the EU's overarching legal framework for mandatory sustainability reporting by companies. It creates a binding obligation for in-scope companies to disclose sustainability-related information on their economic activities, governance, and value chains. The CSRD aims to harmonize sustainability reporting across the EU, addressing inconsistencies and information gaps that previously limited the comparability and reliability of ESG disclosures. The CSRD is further operationalized by the European Sustainability Reporting Standards (ESRS, see below for details).

The CSRD, originally entered into force on 5 January 2023, required Member States to transpose it into national law by July 2024 (Schanke, 2025). The first companies, referred to as wave-1 companies, began reporting in 2025 for the 2024 financial year, while several revisions, including updated deadlines, have since been adopted (these changes are incorporated in the following sections). So-called wave 2 and wave 3 companies will follow according to the schedule set forth in the revised directive. Compliance is overseen by national authorities, and reported information must be independently assured for large companies. Non-compliance may result in sanctions, reputational damage, and legal liability.

Sustainability Dimensions Covered

The CSRD mandates reporting across all three sustainability dimensions—environmental, social, and governance—but does not itself define detailed indicators or metrics. Instead, it specifies minimum thematic areas that must be covered and requires companies to assess the materiality of sustainability topics in relation to their business activities. The specific provisions are outlined in the European Sustainability Reporting Standards (ESRS) (see details below). The CSRD directive formally embeds the principle of double materiality as a core reporting concept, aiming to ensure that both a company's impact on sustainability issues and the effects of sustainability-related factors and risks on the company are transparently disclosed (Recital 29, Directive EU 2022/2464). Additionally, it requires companies to base their disclosures on structured due diligence processes (Article 19a, *ibid.*).

Hydrogen-Specific vs. Generic

The CSRD is technology-neutral and sector-agnostic. It does not contain hydrogen-specific provisions, nor does it distinguish between different hydrogen production pathways. Hydrogen-related activities become relevant only where they are identified as material under the company's double materiality assessment, for example, in relation to climate impacts, energy use, water consumption, biodiversity impacts, or value-chain risks.

Binding vs. Voluntary

Following the Omnibus I revision process, the number of companies affected by the CSRD has been reduced by an estimated 90 percent (Rasche, 2025; Rasche et al. 2025). Under the revised framework, reporting is only mandatory for companies meeting both of the following thresholds: an average workforce of at least 1,000 employees and a net turnover of at least €450 million (Article 19a §1, Directive (EU) 2026/470). For non-EU companies, the CSRD applies if they generate a net annual turnover exceeding €450 million within the EU for each of the last two consecutive financial years and have an EU subsidiary or branch with EU turnover exceeding €200 million (Article 40a, §1, *ibid.*). Companies falling outside this scope may voluntarily report under a future EU sustainability reporting standard based on the VSME framework developed by EFRAG (EC, 2025b). Consequently, smaller EU Member States may have only a small number of companies affected. Germany, the largest EU Member State, may have around 1,600 firms in scope (Rasche, 2025 and Rasche et al., 2025).

Scope

The CSRD applies at the entity level but requires reporting on material sustainability impacts, risks, and dependencies across the entire value chain, including upstream and downstream activities. This encompasses suppliers, contractors, logistics, and use- and end-of-life stages, insofar as they are material. Geographically, the directive applies to EU-based companies and to non-EU companies with significant economic activity in the EU, thereby capturing hydrogen value chains that extend beyond EU borders where linked to EU reporting entities.

European Sustainability Reporting Standards (ESRS)

The European Sustainability Reporting Standards (ESRS), adopted through Commission Delegated Regulation (EU) 2023/2772, operationalize the CSRD by specifying what companies must report and how sustainability information must be disclosed. Developed by the European Financial Reporting Advisory Group (EFRAG) and adopted by the European Commission as delegated acts, the ESRS are legally binding for all companies subject to CSRD reporting obligations.

The standards define reporting principles, structures, disclosure requirements, and key performance indicators (KPIs), thereby ensuring consistency, comparability, and auditability of sustainability disclosures across the EU.

Sustainability Dimensions Covered

The ESRS framework consists of three layers:

1. Cross-cutting standards (ESRS 1 and ESRS 2), which apply to all undertakings regardless of sector
2. Topical standards, covering five environmental standards (ESRS E1–E5), four social standards (ESRS S1–S4), and one governance standard (ESRS G1).
3. Sector-specific standards, which are intended to address sector-specific sustainability risks and impacts; however, none have been formally adopted or made publicly available to date.

ESRS 1 defines general reporting principles, including double materiality, due diligence, and the structure of the sustainability statement. ESRS 2 sets out general disclosure requirements on governance, strategy, impacts, risks, and opportunities, metrics, and targets, which are then specified in detail by each topical standard.

Topical standards are typically structured into sub-topics, and in some cases further into sub-sub-topics. For example, ESRS E1 Climate Change includes sub-topics on climate change adaptation, mitigation, and energy. While a full description of each standard is beyond the scope of this text, Box 4 provides an illustrative example of the requirements under ESRS E4 on Biodiversity and Ecosystems.

Box 4: Example of Requirements under ESRS E4 – Biodiversity and Ecosystems

ESRS E4 requires companies to disclose material impacts, risks, and dependencies on biodiversity and ecosystems across their operations and value chain (*CDR EU 2023/2772, p. 133 – 151*). Key elements include:

- Integration into strategy and governance: Companies must explain how biodiversity considerations are embedded in their business strategy, decision-making, and governance structures.
- Policies and actions: Reporting should cover measures to prevent, mitigate, or compensate negative impacts, including restoration or conservation initiatives.
- Targets and resources: Companies must disclose qualitative or quantitative biodiversity targets, progress against them, timelines, and allocated financial or human resources.
- Value-chain coverage: Disclosures extend to upstream and downstream activities, including suppliers, contractors, and use-phase or end-of-life impacts.
- Location-specific impacts: Companies should report exposure to biodiversity-sensitive or protected areas and land-use changes, including degradation or restoration.
- Due diligence linkage: All disclosures are grounded in the company's sustainability due diligence process and follow the principle of double materiality.

While ESRS are generic, hydrogen-related activities—such as renewable-powered electrolysis projects or infrastructure development may trigger E4 disclosures if they cause material impacts on biodiversity along the value chain.

Hydrogen Specific vs. Generic

Like the CSRD, the ESRS are not hydrogen-specific. However, hydrogen-related activities may trigger reporting obligations under multiple topical standards if deemed material.

Binding vs. Voluntary

The ESRS are mandatory for all companies within the scope of the CSRD and derive their legal force directly from it. In July 2025, the European Commission introduced “quick fix” amendments to the first set of ESRS to reduce reporting burdens and increase certainty for companies that began reporting for the financial year 2024, commonly referred to as “wave 1” companies. These are typically the largest EU companies first required to comply with CSRD reporting obligations. The amendments, effective for 2025–2026, allow wave one companies to omit certain information already excluded in 2024 (EC, 2025c). In parallel, a broader ESRS revision is underway to further simplify reporting requirements in a forthcoming delegated act. This targets the removal of sustainability-related datapoints considered least significant, distinguishes between mandatory and voluntary datapoints, and clarifies provisions related to materiality, among other aspects. Drafts of the revised standards, forming the basis for the delegated act, were published by EFRAG for public consultation and submitted to the Commission in December 2025 (EFRAG, 2025).

Scope

The ESRS require disclosure of material impacts, risks, and dependencies across the full value chain, including hydrogen production, transport, storage, distribution, and end use, where relevant. Reporting is not geographically limited to the EU and includes impacts occurring outside the EU where they are connected to the reporting entity’s activities or value chain and identified as material.

EU Sustainable Finance Disclosure Regulation (SFDR)

The Sustainable Finance Disclosure Regulation (SFDR - Regulation (EU) 2019/2088) is specifically designed for financial market participants (FMPs), requiring them to disclose information regarding their investments and the impact of certain ESG-related criteria on their financial products. The regulation came into effect in March 2021 and is supplemented by various delegated acts. The following detailed disclosure requirements were required to be published for the first time for the financial year 2022 (Siri et al., 2024). On November 20th, 2025, the European Commission published a proposal on revising the regulation substantially, see Box 5 below.

In its original form, the SFDR operates under a multi-level governance scheme that combines EU legislative institutions, national competent authorities, and supervisory bodies to ensure consistent implementation and enforcement across the EU. Its enforcement is carried out at the national level by each EU Member State through their respective regulatory bodies, referred to as National Competent Authorities (NCAs). Penalties for non-compliance are determined individually by each Member State, as the SFDR does not establish a harmonized EU-wide sanctioning framework. Recently, several NCAs have signalled their intention to adopt a more rigorous approach to ensuring compliance with the SFDR (Hausfeld, 2025).

Sustainability Dimensions Covered

The SFDR aims to enhance transparency by requiring Financial Market Participants (FMPs) to disclose both their approach to sustainability risks and the actual or potential negative impacts of their investment decisions. This follows a double materiality approach, assessing both how sustainability factors that may impact the financial performance of investments and how their investment decisions may in turn have significant effects on environmental and social outcomes. Generally, financial market participants are required to make information publicly available on their websites about how they integrate sustainability risks into their investment decision-making processes (Article 3, SFDR). Following a double materiality approach, disclosure of such risks reflects financial materiality, while impact materiality is addressed through the compilation of an annual quantitative report on Principal Adverse Impacts (PAIs, as in Corrigendum to CDR (EU) 2022/1288). For investments made through a fund or other vehicles in an investee company or project, there are 14 mandatory PAIs for which FMPs must provide disclosure (see Table 1 of Annex I of the delegated act, Corrigendum to CDR (EU) 2022/1288).

Beyond these fourteen core (mandatory) indicators, entities must also disclose information on one additional environmental factor (selected from a list of 22) and one additional social or governance factor (chosen from a list of 24), as specified in Tables 2 and 3 of Annex I. These additional indicators must be selected based on whether they are “principal for the financial market participant” (Recital 4, *ibid.*). Additionally, entities must disclose how their selection process considers the likelihood and severity of the impacts, including their

potentially irreversible nature (Article 7, *ibid.*). Box 3 on page 44 illustrates what this may play out in the hydrogen sector in practice.

In addition to organization-wide reporting, FMPs must also disclose sustainability-related information at for certain financial products such as an investment fund. The product-related disclosures are outlined in articles 6, 8, and 9 of the SFDR (Regulation (EU) 2019/2088), distinguishing between financial products with differing types of sustainability objectives:

- *Article 6 Products* – These do not have explicit sustainability objectives but must disclose how they consider sustainability risks and their potential impact on sustainability factors, following the double materiality approach. The goal is to enhance transparency, making investment decisions and advisory processes more informed.
- *Article 8 Products* – These promote environmental or social characteristics but do not have sustainability as their primary objective. Still, ESG factors are integrated into their investment strategy, and PAI disclosure requirements also apply to these products.
- *Article 9 Products* – These funds have a clear sustainable investment objective, focusing on specific environmental or social goals. Investors with strong sustainability ambitions may consider Article 9 funds. PAI disclosure requirements apply here, too, with the extension that an investment must not significantly harm environmental or social goals (along the respective PAIs), and the companies involved must follow good governance practices (such as fair management, good employee relations, responsible pay, and tax compliance (see also Article 2 (17) of SFDR).

Furthermore, all FMPs must disclose the extent to which their products are aligned with the EU Taxonomy, applicable to Article 8 and 9 products. Investments that are aligned with the EU Taxonomy automatically count as sustainable (Article 9) investments under the SFDR (Siri et al., 2024). Please see Box 3 on page 44 to illustrate how these provisions will work in practice.

Hydrogen-Specific vs. Generic

The SFDR sets transparency obligations for financial market participants regarding sustainability-related risks and impacts. It does not contain provisions specific to hydrogen, although investments in hydrogen projects may be reported if relevant.

Binding vs. Voluntary

Under Articles 3–5 of the SFDR, all FMPs with more than 500 employees in a given calendar year are required to disclose, at the organizational level, how they integrate sustainability risks into their investment decision-making processes. This requirement also applies to parent companies of a large group. In general, affected entities include banks, asset managers, insurers, pension funds, credit institutions, and other financial institutions, regardless of whether they offer ESG-focused products. FMPs with fewer than 500 employees are not required to comply with transparency rules but must explain why they do not consider the impacts of investment decisions on sustainability factors, including if and when they plan to do so.

Scope

As described, the EU Sustainable Finance Disclosure Regulation focuses on financial market participants and financial products rather than direct corporate operations. Its scope extends to the underlying assets of investment funds, portfolios, and managed products, requiring transparency on environmental, social, and governance (ESG) risks and impacts across the entire value chain of investee companies. Geographically, the SFDR applies to financial market participants and financial advisors operating in the EU, as well as non-EU entities marketing financial products within the EU, ensuring that sustainability disclosures reflect ESG considerations across global investments that are relevant for European investors. Please see Box 3 on page 44 for illustrating how the SFDR is used by an investment company in practice.

Box 5: The Potential EU SFDR Revision (November 2025; EC, 2025d)

On November 20, 2025, the Commission proposed a revision of the SFDR, intended to simplify sustainability-related disclosures, clarify ESG claims, and better align financial products with investor expectations. The revised framework aims to enhance transparency, comparability, and investor confidence, streamline reporting obligations, and promote meaningful ESG investment, while retaining flexibility for the gradual adoption of sustainable finance practices across the EU.

Simplified Disclosures

The proposal removes entity-level disclosures, including the obligation for Financial Market Participants (FMPs) with more than 500 employees to report principal adverse impacts (with current SFDR in force is an obligation). Product-level disclosures are substantially simplified, with fewer required topics and clearer, more measurable concepts. The complex templates previously mandated under Articles 8 and 9 are eliminated, helping to reduce risks of mis-selling and inconsistent ESG labelling.

Three Voluntary Product Categories

The revision introduces a new voluntary categorization system, grouping ESG-related financial products into three categories based on their sustainability ambition:

- **Sustainable Products:** Invest primarily in companies or projects that already meet high sustainability standards, excluding certain activities (e.g., fossil-fuel extraction or high-emission energy sectors). At least 70% of the portfolio must contribute to a defined sustainability objective.
- **Transition Products:** Focus on companies or projects demonstrating a credible pathway toward improved sustainability performance. Exclusions apply to, for example, firms generating significant revenues from coal or expanding fossil-fuel activities. At least 70% of the portfolio must be aligned with a defined transition strategy, with requirements for monitoring and disclosure of adverse impacts.
- **ESG Basics Products:** Integrate ESG factors broadly without meeting the criteria for the Sustainable or Transition categories. Exclusions include firms generating significant coal-related revenues or expanding fossil-fuel activities. At least 70% of the portfolio must follow an ESG strategy, with performance monitored and disclosed.

Across all three categories, performance must be monitored and disclosed using appropriate indicators. Any principal adverse environmental or social impacts—selected by the FMP—must be transparently reported, including actions taken to address them.

The EU Taxonomy shall continue to serve as a key reference point for identifying environmentally sustainable economic activities. Investments with at least 15% Taxonomy-aligned assets (subject to review after three years) are deemed to meet the 70% positive-contribution requirement, provided the remaining portfolio adheres to exclusion criteria and discloses adverse impacts.

By mid-March 2026, no further developments have been made public.

3.4 Government Funding Schemes

Key Highlights for Hydrogen Sustainability

European Hydrogen Bank (EHB)

- The EHB (formally organized through the EU Innovation Fund) is a CfD-type instrument bridging cost gaps for hydrogen production, primarily awarded based on the lowest bid price.
- The latest EHB auction (IF25 Hydrogen Auction round) offers funding for hydrogen meeting RFNBO criteria, defined in the RED, and electrolytic low-carbon hydrogen, aligned with the definitions in the Hydrogen and Gas Market Directive.
- Since 2025, adherence to Do No Significant Harm (DNSH) criteria toward environmental objectives (as in the EU Taxonomy) is required.

EU Innovation Fund

- In addition to the EHB auctions, the EU Innovation Fund provides funding opportunities for low-carbon technologies across a variety of sectors, including hydrogen production. The IF25 Call for Net Zero Technologies provides €2.9 billion across several project categories.
- Hydrogen production projects must demonstrate GHG emission avoidance relative to a conventional production reference, with minimum thresholds of 50 % for large-, medium-, and small-scale projects and 75 % for pilot projects compared to the EU ETS benchmark for hydrogen (set at 6.84 kg CO₂e/kg H₂).
- Funded projects must comply with the EU Taxonomy's Do No Significant Harm (DNSH) principles, while supply chain due diligence related to environmental, governance, and social risks, among other (non-sustainability related) aspects, is positively considered in the evaluation.
- Projects are being ranked and awarded based on multiple qualitative criteria.

IPCEI Funding

- The IPCEI status in the EU provides access to state aids to support (as for various other areas), as well as a variety of hydrogen projects, to contribute to the EU's strategic goal, such as the European Green Deal
- Funding requirements consider DNSH criteria (as per EU Taxonomy); while formal compliance is not strictly enforced, projects causing environmental damage may be ineligible as environmental or social harms reduce expected positive impacts on competition and trade

European Hydrogen Bank: Auction Mechanism & Sustainability Framework

The European Hydrogen Bank (EHB) is a Contracts-for-Difference-style financing mechanism established by the European Commission to bridge the cost gap between RFNBO-hydrogen and low-carbon hydrogen and their fossil-based alternatives. Primarily awarded on the basis of the lowest bid price, it pays a fixed premium to the awarded projects. Funded by the EU Innovation Fund, the instrument specifically targets hydrogen production. In the first two auction rounds, more than € 1.7 bn were awarded to 22 renewable hydrogen production projects (EC, n.d.-e). In early December 2025, the European Commission started the third auction round for hydrogen (IF25 Hydrogen Auction), open for application until mid-February 2026, with a total budget of €1.3 Billion.

The EHB is overseen by the European Commission in coordination with relevant EU financial and energy authorities. Compliance mechanisms are embedded in funding agreements with project developers, including eligibility assessments, monitoring of milestones, reporting obligations, and verification of financial and technical deliverables. Independent auditors or third-party verifiers may be involved to ensure transparency and accountability.

Sustainability Dimensions Covered

In line with the requirements of the RED II delegated acts, the first two EHB auctions required compliance with EC-RFNBO rules, including geographical and temporal correlation and additionality. Compliance must be demonstrated to be aligned with respective legislation, typically through voluntary certification schemes recognized by the European Commission (CINEA.C.04, 2024a).

Applicants also had to show evidence of having initiated the process of obtaining national environmental permits. Documentation needed to demonstrate that the relevant authority had accepted the start of the application process and that the proposed timeline for obtaining permits before commissioning was realistic (Annex 2, *ibid.*). While permits are issued nationally, they are shaped by EU law; for example, industrial-scale hydrogen

facilities fall under the EU EIA Directive (see Chapter 3.2). Applications were assessed on a pass/fail basis, with successful bids ranked by price.

The call for proposals (CINEA.C.04 – Innovation Fund, 2025) expanded eligibility to electrolytic low-carbon hydrogen production (ibid., p. 13). This must comply with the requirements set out in the Delegated Act on low-carbon hydrogen (CDR (EU) 2025/2359), including its methodology for calculating emissions and an emissions threshold of 3.38 kg CO₂e/kg H₂ (see Chapter 3.2 for details). RFNBO hydrogen producers must follow the rules as set out in the EU RED and the delegated acts (CINEA.C.04 – Innovation Fund, 2025, p. 45).

A part of the EU Innovation Fund, EHB projects must also comply with the "Do No Significant Harm" (DNSH) principles, as defined in Article 17 of the EU Taxonomy Regulation (Regulation (EU) 2020/852; see also Chapter 3.3). The DNSH compliance evaluation in the EHB auctions begins with an assessment of the proposal. Furthermore, projects must also demonstrate to have started the process of acquiring required environmental permits (ibid., p. 14) and outline which water sources are planned to be used (ibid., p. 43).

Hydrogen-Specific vs. Generic

The European Hydrogen Bank provides targeted financial support for hydrogen projects. Its eligibility, compliance, and reporting requirements are tailored specifically to hydrogen.

Binding vs. Voluntary

Participation in EHB-supported programs is voluntary for project developers; however, once funding agreements are signed, adherence to the terms and conditions becomes legally binding. Non-compliance with reporting, performance, or contractual obligations may result in suspension of payments, repayment obligations, or termination of the funding agreement.

Scope

The EHB supports hydrogen production projects. Eligible projects must be located within the EEA, contributing to the EU's domestic hydrogen production targets.

EU Innovation Fund (hydrogen projects beyond the European Hydrogen Bank)

In addition to the European Hydrogen Bank, the EU Innovation Fund also supports hydrogen-related projects through funding calls in support of various net-zero technologies, which are not subject to the EHB's auction-based approach (EC, n.d.-g). Unlike the EHB, grants awarded under the Innovation Fund are open to different hydrogen production pathways. Projects are generally assessed based on their degree of innovation, their GHG emission avoidance potential, project maturity and replicability, cost efficiency as well as additional aspects, for which bonus points may be awarded (CINEA.C.04, 2024b, p. 20). Despite these differences, the governance structure and compliance mechanisms have a similar design to those of the European Hydrogen Bank.

Sustainability Dimensions Covered

In the latest call for proposals, bidders had to ensure GHG emissions reductions of 50% below the EU ETS benchmark applicable to the respective product, while pilot projects had to achieve a 75% reduction (CINEA.C.04 – Innovation Fund, 2026). For hydrogen, the benchmark in the period of 2021–2025 was set at 6.84 kg CO₂e/kg H₂ (EC - Directorate B, 2021)⁹. Consequently, so far, regular hydrogen production projects must achieve GHG emissions of 3.42 kg CO₂e per kg H₂ or lower, while pilot projects must reach 1.71 kg CO₂e per kg H₂. Although hydrogen production pathways are not restricted, RFNBO-compliant hydrogen (as defined in the EU RED) and electrolytic, low-carbon hydrogen (following the definitions of the Hydrogen and Gas Market Directive) are eligible only under the small-scale and pilot project categories (CINEA.C.04 – Innovation Fund, 2026, p. 10)¹⁰. Project developers can improve their chances of receiving funding by achieving even lower levels of GHG emissions, as this contributes to additional scoring.

Furthermore, evaluation criteria consider due diligence measures in applicants' supply

⁹ As the call for proposals was launched on 4 December 2025, the respective emission benchmark of 2025 applies for the latest call, even though funding will be awarded after 2025. New benchmarks will be published for future funding calls.

¹⁰ These two types are funded under the European Hydrogen Bank's IF25 Hydrogen Auction (see section on the EHB above for further details).

chains positively, addressing governance issues, conflict risks, human and social rights, environmental performance, and water risks. They are part of a broader criterion related to strengthening Europe's industrial leadership and competitiveness (CINEA.C.04 – Innovation Fund, 2026, p. 27). While a minimum score must be achieved for this overarching criterion, no minimum score is required specifically for the due diligence component (ibid., p. 30). Finally, any EU ETS revenues allocated to Innovation Fund projects must comply with the DNSH principles of the EU Taxonomy Regulation (Regulation (EU) 2020/852). This means that funded activities must not significantly harm the EU's relevant environmental objectives.

Hydrogen-Specific vs. Generic

While the Innovation Fund supports a broad range of low-carbon and innovative technologies, hydrogen-specific funding streams exist. Eligibility, evaluation, and compliance requirements are partially hydrogen-specific.

Binding vs. Voluntary

The binding nature mechanisms follow a similar structure to those of the European Hydrogen Bank, requiring participants to meet eligibility and reporting obligations.

Scope

Generally, the EU Innovation Fund has a broad technology focus. It covers multiple sectors (see introductory section), which, for the latest call features, among various others, include renewable energy production projects, electrolysis and fuel cell production for hydrogen production and consumption, and hydrogen production itself. Geographic scope is the EU/EEA region.

Important Projects of Common European Interest (IPCEI)

Since 2018, the Commission has approved national state aid for so-called Important Projects of Common European Interest (IPCEI), which are projects crucial in contributing to the EU's strategic goals, such as climate neutrality by 2050, the European Green Deal, and others. Funded projects cover six areas, including the hydrogen value chain, providing financial support for initiatives related to hydrogen technologies, demand-side solutions, infrastructure, and various hydrogen applications in the transport sector. To date, 99 companies across 16 Member States and Norway have been selected to receive up to €18.9 billion in such aid, with the expectation of leveraging more than €27.1 billion in additional private investment (EC, n.d.-a). A project must be significant either in quantitative or qualitative terms, particularly in its size or scope, or involve a substantial level of technological, financial risk, or both.

The European Commission oversees IPCEI approvals and monitors project compliance. Selected projects receive national state aid subject to Commission approval, and member states implement and supervise the funded projects. Compliance focuses on ensuring alignment with the strategic objectives, proper use of financial support, and adherence to environmental criteria.

Sustainability Dimensions Covered

IPCEI projects are expected to contribute to EU strategic objectives, such as climate neutrality and the European Green Deal. Compliance with the 'Do No Significant Harm' (DNSH) principle, as defined in the EU Taxonomy Regulation (Article 17), must be assessed and documented by Member States for projects receiving support. While formal alignment with the EU Taxonomy is not mandatory, the corresponding communication by the EC (2021, Point 20) assumes that projects causing significant harm are unlikely to generate sufficient positive effects (on competition and trade), to offset their negative environmental impact, thus likely becoming ineligible to qualify under IPCEI.

Hydrogen-Specific vs. Generic

IPCEI funding covers multiple strategic sectors, including hydrogen. Within the hydrogen value chain, it supports technologies, infrastructure, demand-side solutions, and transport applications. While hydrogen projects are explicitly included, the framework is still part of a broader, multi-sectoral EU initiative rather than a hydrogen-specific regulatory framework. The sustainability-related provisions are largely generic.

Binding vs. Voluntary

Participation in IPCEI is voluntary; however, projects must meet the conditions set by the European Commission and national authorities to receive funding. Non-compliance with requirements, including strategic alignment and adherence to sustainability principles, may result in withdrawal of support or ineligibility for funding.

Scope

IPCEI projects cover the full hydrogen value chain, divided into four different clusters, ranging from production, infrastructure, transport, and other applications. Geographically, the program spans the EU Member States and Norway (EC, n.d.-a). Projects are selected based on their significance in terms of scale, technological or financial risk, and potential contribution to EU strategic objectives, leveraging substantial private investment in addition to public funding.

3.5 Synthesis of Sustainability Governance in the EU

Tables 2 - 4 below provide a summary and comparative analysis of key EU regulations and initiatives concerning the sustainability of hydrogen, drawing on the categories outlined in Chapter 2.6.

The Renewable Energy Directive (RED II and its amendments under RED III) remains the only EU regulation that directly addresses hydrogen, and that has a (partial) focus on sustainability. Its scope is largely confined to climate-related and renewability aspects. Broader sustainability dimensions are not central to hydrogen-specific EU regulatory frameworks.

Despite this limited scope, environmental and social safeguards are introduced through a range of indirect mechanisms embedded in broader EU regulatory and funding instruments:

1. *Application of General EU Environmental Law*

Hydrogen production projects within the EU that produce at “industrial scale” fall under general EU environmental legislation. This includes the Environmental Impact Assessment (EIA) Directive, which incorporates public participation procedures and thus allows for partial consideration of social dimensions. Although not tailored specifically to hydrogen, these requirements are established and tested across multiple (energy) sectors.

2. *Environmental Safeguards in EU-Funded Projects*

In addition to the general requirement to conduct an EIA, projects receiving EU funding through the regular Innovation Fund and the European Hydrogen Bank must comply with the Do No Significant Harm (DNSH) criteria set out in the EU Taxonomy)¹¹.

3. *Corporate Sustainability Due Diligence Directive (CSDDD)*

These environmental regulations are complemented by the EU’s supply chain law, the CSDDD. This requires companies to identify, assess, and actively mitigate salient environmental and human rights risks and implications throughout their operations and global value chains. Altogether, the frameworks contribute to the broader governance of environmental and social aspects related to hydrogen, even in the absence of direct hydrogen-specific mandates.

4. *Transparency and Disclosure Mechanisms*

The EU leverages several disclosure and transparency instruments to indirectly promote sustainability across the hydrogen value chain, applying for investments into hydrogen, for hydrogen purchasers, and hydrogen producers, in different ways:

- The EU Taxonomy provides a classification framework for environmentally sustainable economic activities. Compliance with the Do No Significant Harm (DNSH) Criteria, for example, requires demonstrating that biodiversity and ecosystem integrity are not adversely affected by conducting an Environmental Impact Assessment in accordance with the EU EIA Directive.
- Under the Sustainable Finance Disclosure Regulation (SFDR), financial market participants are required to report on 18 standardized

¹¹ The DNSH criteria described here, refer to hydrogen production projects. See respective sections in Chapter 3.3 and 3.4 for more details.

environmental and social indicators, alongside disclosing integration of sustainability risks in their investment decisions (double materiality).

- The Corporate Sustainability Reporting Directive (CSRD) requires large companies to disclose their sustainability strategies in line with the European Sustainability Reporting Standards (ESRS), including information on sustainability risks and impacts related to their economic activities, as well as the impacts of their activities on environmental and social factors (double materiality).

That said, sustainability-related legislation in the EU is in the process of being simplified. In some cases, amendments have already been completed, e.g., for the Corporate Sustainability Due Diligence Directive (CSDDD) and the Corporate Sustainability Reporting Directive (CSRD). First simplifications have also been implemented in the EU Taxonomy. For many other environmental regulations, amendments are scheduled for 2026, including:

- ESRS: A broader revision of the European Sustainability Reporting Standards (published through a Delegated Act by September 2026) is underway to simplify reporting requirements, clarify ambiguous provisions, and improve alignment with other EU legislation. Drafts were published in 2025 and have already undergone a public consultation phase.
- EU SFDR: Significant restructuring was proposed, including the creation of new product categories and simplified disclosure requirements. The European Commission published its proposal in November 2025.
- EU EIA Directive and EU Industrial Emissions Directive (IED): Simplification of environmental assessments and targeted exemptions for certain industrial installations, particularly regarding NO_x emissions when hydrogen is used for co-firing. Currently, a Commission proposal exists (December 2025).

An additional observation is that the requirement to use renewable energy sources for hydrogen production is specified in the EU Renewable Energy Directive (RED), which aims to promote renewable hydrogen transport and industry. It has been supported by the European Hydrogen Bank (EHB), which has launched auctions dedicated to renewable hydrogen. However, other funding mechanisms, such as the Innovation Fund and the latest EHB auctions, have also supported other low-carbon hydrogen technologies. Finally, broader environmental aspects are covered in public funding programs across the EU, while social aspects are only integrated within the EU Taxonomy regulation in the form of minimum social safeguards.

TABLE 2: REGULATION OF ECONOMIC ACTIVITIES IN THE EU

Governance Instruments	Sustainability Dimensions Covered				Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
	Climate	Renewability	Environment	Social				
Regulation of Economic Activities								
EU Renewable Energy Directive (RED)	X	X			Specific	Voluntary for the individual actor	Domestic Production and Import into the EU	Defined criteria for qualifying H ₂ as an RFNBO. Member States are responsible for ensuring that EU-wide RFNBO production and consumption targets are achieved. No mandatory requirement for the individual producer to produce RFNBO-H ₂ .
EU Hydrogen & Gas Decarbonisation Package	X				Specific	Voluntary	Domestic Production and Import into the EU	Among other aspects features a methodology for GHG emission calculations for low-carbon hydrogen. Low-carbon hydrogen has the same emission thresholds as in RED for RFNBO-hydrogen. The EU has not set quantitative targets for low-carbon hydrogen.
EU ETS & CBAM	X				Generic & Specific	Binding for certain actors	Domestic Production (EU ETS) & Import (CBAM). Indirectly, for hydrogen consumers to use alternative fuels	Binding for hydrogen production facilities in the EU and EEA that produce >5t H ₂ / day, and for various consumers of fuels in other sectors, incentivizing the usage of more climate-friendly fuel, e.g., RFNBO hydrogen and low-carbon hydrogen. CBAM applies to hydrogen imports from the first tonne, and to hydrogen derivatives above 50 t/a.
EU Corporate Sustainability Due Diligence Directive (CSDDD)			X	X	Generic	Binding for certain actors	Domestic Production and Imports into the EU. Focus on value chain parts and actors where impacts are most severe or most likely to occur	CSDDD introduces the obligation for companies with ≥5,000 employees and ≥€1.5 billion in turnover in the EU to conduct sustainability-related due diligence for their supply chains
Environmental Impact Assessment (EIA) Directive			X	(X)	Generic	Binding in most cases	Domestic production and non-EU initiatives involving EIB project financing.	Binding for industrial-scale hydrogen production at integrated chemical facilities. Public and stakeholder participation is a mandatory element of the EIA process, in this way addressing social concerns and impacts.
EU Industrial Emission Directive (IED)			X	(X)	Generic	Binding for certain actors	Domestic Production	Binding, for projects producing >50 tonnes per day of electrolytic hydrogen, and for other production pathways from the first tonne. Similar public participation process as in the EIA Directive.

Source: Authors

TABLE 3: TRANSPARENCY AND DISCLOSURE MECHANISMS IN THE EU

Governance Instruments	Sustainability Dimensions Covered				Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
	Climate	Renewability	Environment	Social				
<i>Transparency & Disclosure Mechanisms</i>								
EU Taxonomy	X		X	X	Generic and Specific	Binding for certain companies	Domestic Production and Import into the EU	Mandatory for products that are marketed as environmentally sustainable, aligned with EU Taxonomy; generally voluntary, but large firms must disclose the extent of alignment (e.g., with DNSH criteria); includes hydrogen-specific GHG methodology and threshold (3 kg CO ₂ /kg H ₂ ; Methodology only partly aligned with EU RED); other E&S aspects refer to general regulations.
Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS)	X		X	X	Generic	Binding for certain Companies	Targeted at (potential) H ₂ consumers with implications for domestic producers and imports into the EU	Legislative framework requiring large companies in or doing business in the EU to disclose their impacts on five environmental, four social, and one governance topic, as well as how these factors affect their business, based on the principle of double materiality. Binding for certain large companies in the EU or with a certain turnover in the EU. Simplifications have been implemented through the revision of the CSRD directive to reduce scope (affecting the number of companies under the CSRD); ESRS simplifications are currently being developed.
Sustainable Finance Disclosure Regulation (SFDR)	X		X	X	Generic	Binding for certain Financial Market Participants	Targeted at investments & funds with implications for domestic producers and imports into the EU	EU framework requiring financial market participants to disclose the sustainability impacts (no strict sustainability criteria – only reporting). Disclosure requirements include 14 mandatory environmental and social indicators (PAIs), 1 optional environmental indicator (from a list of 22), and 1 optional social/governance indicator (from a list of 24). Renewable energy is not strictly required under SFDR Articles 8 & 9, but it eases alignment with the EU Taxonomy and SFDR sustainability criteria, as goods classified under Articles 8 and 9 goods are required to disclose to what degree they are taxonomy-aligned. In November 2025, a proposal to revise the SFDR was published by the European Commission.

Source: Authors

TABLE 4: GOVERNMENT FUNDING SCHEMES IN THE EU

Sustainability Dimensions Covered								
Government Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Government Funding Schemes								
European Hydrogen Bank (IF25 Hydrogen Auction)	X	(X)	X		Specific	Voluntary*	Hydrogen production projects in the EU/ EEA.	Applicants must show evidence of national environmental permits at financial close. Auction Rounds 1–2 required RFNBO compliance; Round 3 (IF25 Hydrogen Auction) extends eligibility to electrolytic low-carbon hydrogen and requires adherence to the EU Taxonomy's DNSH criteria.
EU Innovation Fund (IF25 Call for Net-Zero Technologies)	X		X	(X)	Specific and Generic	Voluntary*	Alongside various sectors, hydrogen projects across different segments of the value chain (e.g., production and end use) and at different scales are supported within the EU/ EEA.	Hydrogen production projects must demonstrate GHG emission avoidance relative to a conventional production reference, with minimum thresholds of 50 % for large-, medium-, and small-scale projects and 75 % for pilot projects compared to the EU ETS benchmark for hydrogen (with this call set at 6.84 kg CO ₂ e/kg H ₂). Funded projects must comply with the Taxonomy's DNSH principles, while supply chain due diligence related to environmental, governance, and social risks, among other (non-sustainability related) aspects, is positively considered in the evaluation. Projects are being ranked and awarded based on multiple qualitative criteria.
Important Project of Common European Interest (IPCEI)	(X)	(X)	(X)		Specific and Generic	Voluntary*	Various segments of the hydrogen value chain: production, storage, transportation, end user applications in the EU/ EEA.	IPCEI-projects contribute to EU strategic goals, which could mean contributing to climate mitigation through renewable energy sources. EU Taxonomy alignment: Compliance with DNSH criteria is not mandatory, but is generally expected (projects may need to align anyway, due to other IPCEI requirements)

Source: Authors

*Requirements are binding if projects want to be eligible and apply for funding through these mechanisms.

4 Sustainability Governance in the U.S.

This chapter presents the emerging hydrogen-related sustainability governance in the United States. Based on the framework presented in Chapter 2, it reviews strategies, policies, regulations, and funding schemes in the U.S. that influence sustainability outcomes in the hydrogen sector. This includes both hydrogen-specific governance mechanisms and broader sustainability governance with implications for the hydrogen sector

4.1 U.S. Hydrogen Strategy and Overarching Policies

In 2023, the Biden-Harris Administration released the first-ever U.S. National Clean Hydrogen Strategy and Roadmap (DOE, 2023a, 2023b) outlining a strategic vision to scale clean hydrogen production and deployment as a key component of national decarbonization efforts across critical sectors. The strategy sets ambitious production targets: 10 million metric tonnes (MMT) annually by 2030, 20 MMT by 2040, and 50 MMT by 2050.

The U.S. Department of Energy (DOE) defines clean hydrogen as hydrogen produced via various pathways that meet strict greenhouse gas (GHG) intensity thresholds—specifically, less than 2 kg CO₂-equivalent per kg H₂, considering greenhouse gas emissions at the site of production (gate-to-gate system boundary)¹². This definition was established under the Bipartisan Infrastructure Law (BIL), officially known as the Infrastructure Investment and Jobs Act (IIJA), signed into law by President Biden on November 15, 2021 (DOE, 2023c). The BIL also initiated the Clean Hydrogen Production Standard (CHPS, see Chapter 4.2) and allocates \$62 billion to energy-related initiatives, including \$8 billion for the Regional Clean Hydrogen Hubs Program (H2Hubs), \$1 billion for clean hydrogen electrolysis, and \$500 million for clean hydrogen manufacturing and recycling (DOE, 2023a; Eicke, 2025).

The overall strategy follows a phased approach: by 2030, clean hydrogen targets ammonia, refining, and petrochemicals; by 2040, it expands to heavy transport and storage; and by 2050, to advanced uses such as power-to-liquids and system integration, alongside a major biofuel scale-up. Initially focused on domestic markets, the strategy shifts after 2030 toward exports and positioning the U.S. as a global supplier (DOE, 2023b).

From a sustainability perspective, the Hydrogen Strategy and Roadmap is grounded in eight guiding principles that direct coordinated action across federal, state, local levels of government, and tribal jurisdictions, alongside industry and community stakeholders. Among these, a focus is placed on enabling deep decarbonization through strategic, high-impact uses of hydrogen, taking a holistic approach that integrates hydrogen across sectors and energy systems, advancing energy and environmental justice to ensure equitable outcomes, fostering diversity, equity, inclusion, and accessibility throughout the hydrogen value chain, and creating high-quality jobs that support a just and inclusive clean energy transition (DOE, 2023b). Additionally, the roadmap is aligned with, and intended to contribute to, the Justice40 Initiative—established under President Biden’s administration—which seeks to ensure that at least 40 percent of the benefits from key federal investments, including those in clean energy, climate resilience, and housing, flow to disadvantaged communities that have historically experienced underinvestment and disproportionate environmental burdens (The White House, n.d.). While the roadmap and strategy remained untouched during the Trump administration, the Justice40 Initiative and funding were revoked entirely (Harvard Law School, 2025; Rushing, 2025).

¹² Based on this definition, the Clean Hydrogen Production Standard (CHPS, see Chapter 4.2) establishes a targeted emission threshold of 4 kgCO₂e/kg for clean hydrogen, using well-to-gate system boundaries (DOE, 2023c). The CHPS emissions threshold is typically the threshold that is used in regulatory contexts in the USA.

4.2 Regulation of Economic Activities

Key Highlights for Hydrogen Sustainability

Clean Hydrogen Production Standard

- Establishes a high-level methodology for GHG emission calculations across multiple production pathways (well-to-gate system boundary).

Regional Clean Hydrogen Hubs Program

- Designed to accelerate the U.S. hydrogen economy; initially included seven hubs, with two defunded under the second Trump administration.
- Hubs must develop Community Benefits Plans to engage local communities and create local benefits.
- Historically linked to the Justice40 Initiative (discontinued), which aimed to direct at least 40% of benefits from federal investments, including clean energy, to disadvantaged communities disproportionately affected by environmental burden and underinvestment.
- Federal support and continuity remain uncertain under the current presidency.

National Environmental Policy Act (NEPA)

- Governs federal environmental impact review through a three-tiered process, triggered by a major federal action (e.g., where a project receives federal funding or requires federal permitting)
- Agencies are legally mandated to evaluate ecological, social, and cultural impacts
- Following the 2026 rescission of the centralized CEQ oversight, the Department of Energy (DOE) and other agencies now lead independent reviews.

Low-Carbon Fuels Standard (California)

- The program is designed to reduce GHG emissions from transportation fuels through a credit-trading system.
- Hydrogen, whether for direct use in FCEVs or as feedstock for synthetic fuels supplied in California, must meet progressively lower lifecycle GHG emission thresholds (well-to-wheel system boundary).
- To qualify as low-carbon or renewable, the electricity used must satisfy California-specific deliverability, additionality beyond existing mandates, and time correlation requirements (generation within three calendar quarters).
- From 2035, fossil-derived hydrogen will be fully ineligible for credits

Clean Hydrogen Production Standard (CHPS)

The Clean Hydrogen Production Standard (CHPS) was developed in 2022 in response to the Bipartisan Infrastructure Law (BIL) enacted in 2021. The DOE released the draft CHPS in September 2022 and finalized it in 2023, establishing the emissions threshold and guidance for implementation across federal clean hydrogen programs. Compliance is monitored through the Internal Revenue Service (IRS) and the Department of the Treasury. Both agencies ensure that hydrogen producers meet the specified lifecycle greenhouse gas emissions criteria to qualify for financial incentives (DOE, 2023c).

Sustainability Dimensions Covered

The CHPS establishes a carbon intensity of no more than 4 kg CO₂-equivalent per kilogram of hydrogen produced, following a well-to-gate system boundary. This is considered equivalent to the DOE's initial definition of clean hydrogen, which stipulated a threshold of 2 kg CO₂e per kg of hydrogen on the basis of a gate-to-gate system boundary (DOE, 2023c). The CHPS threshold is aligned with the highest allowable carbon intensity under Section 45V of the Inflation Reduction Act (IRA) for eligibility for clean hydrogen tax credits (see Chapter 4.4 for more details).

The CHPS outlines a general methodological framework that balances technological feasibility and economic viability to ensure its applicability across a wide range of hydrogen production methods. It covers hydrogen produced from fossil fuels combined with carbon capture, utilization, and storage (CCUS); hydrogen-carrier fuels such as ethanol and methanol; renewable sources such as biomass; and nuclear energy. The standard accounts for upstream emissions, including those associated with electricity generation and fugitive emissions, as well as downstream processes necessary to ensure that captured CO₂ is securely and durably sequestered. It explicitly excludes the use phase of hydrogen from

its system boundary. The specific emission factors and CO₂ intensities of individual steps in hydrogen production are detailed in the so-called R&D GREET Model¹³ (DOE, 2023c).

Hydrogen-Specific vs. Generic

The CHPS is a hydrogen-specific framework designed to define and incentivize clean hydrogen production in the United States.

Binding vs. Voluntary

The CHPS itself is a guidance document and does not impose binding regulations. However, compliance with its standards is required to qualify for financial incentives under Section 45V under the Inflation Reduction Act (see Section 4.4). Therefore, while the CHPS provides a framework, adherence to its guidelines is necessary to access federal support.

Additionally, the CHPS serves as an important policy tool guiding the allocation of federal funding for hydrogen-related projects and supports the broader scale-up of low-carbon hydrogen production across the United States (DOE, 2023a).

Scope

The CHPS focuses on the production phase of the hydrogen value chain, setting standards for the lifecycle greenhouse gas emissions associated with hydrogen production. It does not extend to downstream applications or infrastructure development. Geographically, the standard applies to hydrogen production facilities within the United States, with specific provisions for the use of renewable energy sourced locally to ensure the environmental integrity of the produced hydrogen.

Regional Clean Hydrogen Hubs (H2Hubs) Program

As part of the BIL, the DOE has established the Regional Clean Hydrogen Hubs (H2Hubs) Program, with an original funding allocation of US\$7 billion of public capital across seven regions in the United States. For example, the Pacific Northwest Hub spans Washington, Oregon, and Montana. This initiative aims to facilitate the demonstration and development of integrated networks involving clean hydrogen producers, potential consumers, and the necessary infrastructure to connect them. The hubs will focus on advancing the production, processing, delivery, storage, and end-use of clean hydrogen, promoting both sustainable and equitable regional benefits, as well as accelerating market adoption (DOE, 2023a).

By January 2025, five of the seven designated hubs had received an initial portion of their overall funding allocation to begin Phase 1 activities (For details about the tasks in the different phases, see the overview by EarthJustice, 2025). At this stage, none of the Regional Clean Hydrogen Hubs are operational. In October 2025, the U.S. Department of Energy cancelled funding for two of seven federally backed Regional Clean Hydrogen Hubs, the California-based ARCHES hub and the Pacific Northwest Hydrogen Hub, originally allocated with up to totally US\$ 2.2 bn, while the funding for the other hubs (still) remains in place (Martin, 2025b).

While not a traditional governance tool, since it supports regional hydrogen value chains rather than directly regulating producers, it is included here due to its significant funding, broad coverage, interaction with other federal instruments, and a few sustainability requirements, as outlined in the following.

Sustainability Dimensions Covered

The CHPS is the guiding framework (see above) for the DoE's hydrogen-related initiatives, including the H2Hubs Program. Additionally, the provisions authorize the DoE to select projects that do not fully meet the CHPS threshold, provided they “demonstrably aid the achievement” of the CHPS by reducing emissions across the supply chain to the greatest extent possible—for example, through robust onsite carbon capture, mitigation of fugitive methane emissions, or the use of clean electricity. Still, compliance with the CHPS may be given preferential consideration (DOE, 2023c).

¹³ GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) models energy use and greenhouse gas emissions across the full life cycle of fuels, vehicles, and technologies. It provides default emission factors and can be used to simulate specific hydrogen production pathways, with R&D GREET results compared against the CHPS threshold. For the IRA 45V tax credit and the Low Carbon Fuels Standard (LCFS), dedicated GREET versions are available.

Each hub is also required to implement a Community Benefits Plan (CBP), detailing engagement with local communities, accountability measures, and initiatives to deliver tangible social and environmental benefits. The plans should also detail concrete measures to deliver local benefits and mitigate potential harms, particularly in communities historically affected by environmental injustice. Hubs being in Phase 1 of the program were originally designed to support the goals of the Justice40 Initiative, which was terminated under the current U.S. Presidency. Hubs are subject to environmental review under the National Environmental Policy Act (NEPA), which may include the preparation of an Environmental Impact Statement (Rebel & Smith, 2024).

Hydrogen-Specific vs. Generic

The H2Hubs program is hydrogen-specific, targeting integrated regional networks that connect hydrogen producers, consumers, and infrastructure. It focuses explicitly on advancing the production, processing, delivery, storage, and end-use of clean hydrogen, distinguishing it from broader energy programs or generic infrastructure funding.

Binding vs. Voluntary

Participation in the H2Hubs program is voluntary; however, selected projects must comply with DOE requirements to retain funding. Non-compliance may result in reduced or withdrawn support, emphasizing the conditional and performance-based nature of the program.

Scope

The H2Hubs program covers the entire hydrogen value chain, including production, processing, transport, storage, and end-use applications. Geographically, seven regional hubs have been designated across the United States—for example, the Pacific Northwest Hub spans Washington, Oregon, and Montana—creating a network intended to accelerate market adoption and regional clean hydrogen integration.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA) serves as the primary procedural framework for environmental governance in the United States¹⁴. Following Executive Order 14154 (January 2025) and the subsequent rescission of binding procedures issued by the Council on Environmental Quality (CEQ), the implementation of NEPA has transitioned from a centralized model to a decentralized approach, led by the respective agencies. Although the CEQ no longer issues government-wide binding regulations (see Harvard Law School, 2026, for an overview), the core of NEPA remains intact as it was codified into national law via the Fiscal Responsibility Act of 2023 (FRA, 2023).

Consequently, while individual agencies like the Department of Energy (DOE) and Department of the Interior (DOI) issued their own specific NEPA procedures in February 2026 (See DOE, 2026 and DOI, 2026), they must still adhere to the statutory mandates of the FRA. This stipulates a three-tiered approach consisting of Categorical Exclusions (CA-TEX), which do not require detailed analysis, Environmental Assessments (EA), and Environmental Impact Statements (EIS). The FRA also introduced a number of measures to streamline review procedures, such as mandatory time and page limits (FRA, 2023).

Sustainability Dimensions Covered

NEPA does not define a specific set of environmental aspects to be considered in decision-making. Instead, its scope is broad. Following the Fiscal Responsibility Act, agencies must evaluate (FRA, 2023):

- **Foreseeable Environmental Impacts:** Assessing the direct, indirect, and cumulative effects of a proposed action.
- **Unavoidable Adverse Effects:** Documenting impacts that cannot be mitigated.
- **Alternatives Analysis:** Considering technically and economically feasible alternatives
- **Balancing:** Weighing short-term uses of the environment against the maintenance of long-term productivity.
- **Resources:** Identifying any irreversible or irretrievable commitments of federal resources.

¹⁴ Importantly, various U.S. states, in addition to federal NEPA provisions, have implemented their own environmental regulations, to assess and manage potential environmental impacts at the regional or state level (See, for instance, Wang et al., 2023), which are not covered in this study.

Overall, this encompasses ecological, social, cultural, and economic impacts, providing a comprehensive, though procedural, sustainability assessment.

Hydrogen-Specific vs. Generic

The NEPA is a generic framework applicable to all major federal actions. However, its application to the hydrogen sector is increasingly specified through the procedures by the involved agencies. The 2026 implementing procedures from DOE establish an extensive list of project types that are automatically classified under this category (DOE, 2026); however, hydrogen production projects are largely not included, meaning that likely, the following second level of assessment (Environmental Assessment) is triggered.

Binding vs. Voluntary

NEPA procedures must be followed for any project where any “major federal action” is required. It applies primarily under the following conditions (CEQ, 2021):

1. **Federal Funding:** Projects that are financed in whole or in part by the federal government are subject to NEPA. For example, the Regional Clean Hydrogen Hubs will likely require an Environmental Impact Statement (Rebel & Smith, 2024)¹⁵.
2. **Federal Permits or Approvals:** If a project requires a federal permit (e.g., the Clean Water Act or Clean Air Act) or is built on federal land, NEPA compliance is a prerequisite for project approval.
3. **Substantial Federal Control:** Under the FRA 2023, NEPA only applies if the federal agency has “substantial control” over the project’s outcome. Projects with minimal federal funding or where the federal role is purely ministerial may be exempt

Scope

NEPA covers the entire value chain of a project (triggered by the described cases above), including production, processing, transport, and infrastructure activities. Geographically, its scope is nationwide, but assessments are project-specific, focusing on the environmental impacts within the regions where the project operates or influences.

Low-Carbon Fuels Standard (LCFS) California

The Low-Carbon Fuel Standard (LCFS), implemented in California in 2011, is a regulatory framework aimed at reducing GHG emissions from the transportation sector, decreasing reliance on petroleum-based fuels, and promoting innovation in low-carbon fuel technologies. (California Energy Commission, 2025). The program serves as an example among several targeted regional initiatives implemented across various states. The LCFS is a central component of the state’s climate strategy, aiming to reduce GHG emissions by 20% by 2030 and 80% by 2050. Unlike typical cap-and-trade systems, such as the EU ETS, which cap total sectoral emissions, the LCFS specifically targets the carbon intensity of specific transportation fuels.

The LCFS is administered by the California Air Resources Board (CARB), which sets annual carbon intensity targets for transportation fuels. Fuel producers, importers, and distributors must monitor, report, and verify the lifecycle greenhouse gas emissions of the fuels they supply. Compliance is achieved either by reducing the carbon intensity of supplied fuels or by purchasing LCFS credits from entities that exceed reduction requirements. CARB oversees verification through accredited third-party verifiers, enforces reporting obligations, and can impose penalties or corrective actions for non-compliance, ensuring the integrity and effectiveness of the program.

Sustainability Dimensions Covered

The LCFS functions through a credit-based market mechanism, similar to an emissions trading system. Fuel producers, importers, and distributors earn credits when supplying fuels with a carbon intensity (CI) below a specified benchmark, which is established for various fuel categories and is progressively reduced over time. For instance, the CI benchmark for diesel is 81.70 gCO₂e/MJ in 2025 (equivalent to approximately 294.12 gCO₂e/kWh), declining to 10.57 gCO₂e/MJ by 2045 (CARB, 2025, p. 65). For hydrogen specifically, no such benchmark exists. Entities supplying fuels with higher CI values must

¹⁵ The research for this publication did not yield a definitive answer whether projects that benefit from tax credits under Section 45V of the Inflation Reduction Act (see Chapter 4.4) are considered to receive federal funding or grants, and therefore would automatically trigger the NEPA review process, due to partly conflicting information and the absence of official government documentation.

purchase credits to comply. This system creates a financial incentive to invest in low-carbon fuel production.

For GHG emission calculations, the LCFS employs a well-to-wheel emissions approach, accounting for both production and use phases—unlike many international schemes focused only on upstream emissions. When hydrogen is used as a feedstock for synthetic fuels, its emissions are included in the final product's life-cycle CI. This incentivizes low-CI hydrogen, as it reduces the synthetic fuel's CI and increases credit potential under the LCFS. GHG emission intensity can be demonstrated through various methods

Firstly, hydrogen producers may report CI using default values (CARB, 2018), using a California-specific GREET model, such as:

- Electrolytic H₂ (100% wind/solar): 10.51 g CO₂e/MJ (~1.26 kg CO₂e/ kg H₂)
- Electrolytic H₂ (CA grid): 164.46 g CO₂e/M (~19.72 kg CO₂e/ kg H₂)
- SMR H₂ (liquefied): 150.94 g CO₂e/MJ (~18.11 kg CO₂e/ kg H₂)

To qualify under the CI benchmark of electrolytic hydrogen, among other rules, the following additional conditions must be met, typically verified through Renewable Energy Certificates (RECs) (CARB, 2022, p. 2):

- *Deliverability* (geographical correlation): Electricity must be generated within or deliverable to a California Balancing Authority.
- *Additionality*: Electricity must exceed existing renewable energy mandates.
- *Time Correlation*: Generation and fuel use must occur within three calendar quarters.

Producers may alternatively utilize the Tier 2 pathway to report the actual greenhouse gas emissions associated with renewable hydrogen production, based on real-world data and modelling. This pathway offers significantly greater flexibility, for instance, allowing the use of various electricity sources, but requires comprehensive and specific documentation, as well as third-party verification and auditing. Provided that the carbon intensity of gaseous hydrogen does not exceed 55 gCO₂e/MJ (approximately 6.6 kg CO₂e/kg H₂) (CARB, 2025, p. 187), the Tier 2 pathway is possible to be followed. In summary, while the Tier 2 approach provides enhanced flexibility, it also involves increased complexity and administrative effort.

Generally, the LCFS focuses on GHG emission intensity, including the use phase, and does not address broader environmental or social sustainability criteria (see also Gale et al., 2024).

Hydrogen-Specific vs. Generic

The LCFS includes specific pathways for hydrogen (among others) to earn credits if their CI is sufficiently low. Beyond hydrogen, the LCFS allows a range of lower-carbon fuels and technologies to help replace or reduce the use of higher-carbon fossil-based fuels.

Binding vs. Voluntary

With amendments to the LCFS taking effect on July 1, 2025, at least 80% of the hydrogen used in California's transportation sector must be renewable by 2030. Under LCFS definitions, 'renewable hydrogen' refers to hydrogen produced via electrolysis powered by renewable electricity, reforming of biomethane or other renewable hydrocarbons, or thermochemical conversion of biomass, including municipal solid waste (CARB, 2025, p. 22). While the production of non-renewable hydrogen will still be permitted, its eligibility for LCFS credit generation will be limited to a maximum of 20%, regardless of its carbon intensity. In other words, no more than 20% of non-renewable hydrogen may contribute to credit generation under the program, even though its specific GHG emission intensity would remain below the respective CI benchmark. Starting in 2035, fossil-derived hydrogen will be entirely ineligible for LCFS credits (CARB, 2025, p. 34).

Scope

Hydrogen can generate LCFS credits through two primary pathways: (1) direct use in fuel cell electric vehicles (FCEVs), both light- and heavy-duty; and (2) as a feedstock for the production of synthetic fuels. Generally, the LCFS applies to all transportation fuels sold, supplied, or offered for sale within California, with some exemptions. As such, alternative fuels (not biomass-based) whose total annual supply in California remains below 3.6 million gasoline gallon equivalents are exempt from LCFS obligations. Additional exemptions exist for specific fuel types and applications, including fossil jet fuel and deficit-generating fuels

(fuels with carbon intensities exceeding the regulatory standard)(CARB, 2025, p. 32 - 33). The LCFS program enables producers and importers to generate, acquire, transfer, bank, borrow, and trade credits to facilitate compliance (ibid., p.53).

4.3 Transparency and Disclosure Mechanisms

Key Highlights for Hydrogen Sustainability

- At the federal level, no established transparency or disclosure requirements specific to hydrogen have been identified.
- California Transparency in Supply Chains Act (CTSCA): May apply to hydrogen value chain companies exceeding certain revenue thresholds. The Act requires affected companies to publicly report measures taken to address human trafficking and slavery within their supply chains.

At the federal level, formal transparency mechanisms for hydrogen are limited. The Clean Hydrogen Production Standard helps compare GHG intensities across production pathways, but most disclosure relies on voluntary ESG frameworks (see Chapter 8.2) and, to a lesser extent, state-level regulations such as those in California, as described in the following.

California Transparency in Supply Chains Act (CTSCA)

The California Transparency in Supply Chains Act (CTSCA), enacted in 2010, mandates that certain companies subject to the Act must publicly disclose their efforts to address human trafficking and slavery in their supply chains in different areas. In that regard, companies are responsible for monitoring and reporting their supply chain practices annually through publicly accessible disclosures. While the Act does not prescribe a centralized enforcement body, compliance is overseen by California's Attorney General, who can investigate potential violations and pursue legal action. Companies are not required to conduct audits but must disclose whether they do. If audits are performed, companies must state whether they are conducted by independent third parties and whether they are announced or unannounced. The goal with this proceeding is to provide transparency, not to mandate specific auditing practices (DOJ, 2015).

Sustainability Dimensions Covered

The act requires affected companies to publicly disclose their efforts to address human trafficking and slavery in their supply chains across five key areas: how they verify supply chain risks, whether supplier audits are conducted and if they are independent or unannounced, whether suppliers are required to certify compliance with relevant laws, what internal accountability measures are in place, and whether employees receive relevant training. These disclosures must be made publicly available, typically on the company's website (DOJ, 2015).

Hydrogen-Specific vs. Generic

The CTSCA is a generic regulatory framework addressing human rights and labor practices across global supply chains. It does not include hydrogen-specific provisions or technical requirements for hydrogen production or use.

Binding vs. Voluntary

The CTSCA is binding to retail sellers and manufacturers of goods that conduct business in California and have annual worldwide gross revenues exceeding \$100 million. Hydrogen producers are not automatically subject to the Act. However, companies that meet the Act's criteria—conducting business in California and having annual worldwide gross revenues exceeding \$100 million—are required to comply with its disclosure obligations (DOJ, 2015). This may include large international energy corporations or industrial gas producers with hydrogen production operations seeking to sell hydrogen or hydrogen-based fuels in California.

Scope

The California Transparency in Supply Chains Act (CTSCA) applies to a company's entire global supply chain, encompassing upstream suppliers, manufacturers, and service

providers that contribute to the production of goods sold in California. Companies must report on practices across all tiers of their supply chain, including raw material sourcing, production, and distribution activities. While the law is California-specific in scope, its requirements extend to operations worldwide, as companies must account for suppliers outside the U.S. to ensure comprehensive disclosure.

4.4 Government Funding Schemes

Key Highlights for Hydrogen Sustainability

Inflation Reduction Act Tax Credits 45V

- Provides substantial government funding for hydrogen producers through tax credits, contingent on meeting lifecycle greenhouse gas emission thresholds, ranging from a maximum emission intensity of 0.45 kg CO₂e/kg H₂ for the highest credit to an upper limit of 4 kg CO₂e/kg H₂.
- Supports multiple hydrogen production pathways, including electrolytic, methane-based, and others.
- Eligibility requirements include compliance with prevailing wage standards and the employment of a minimum number of registered apprentices.
- Under the current administration, hydrogen producers must commence construction by the end of 2027 to be eligible for the tax credit, with all other eligibility requirements remaining in effect.

Inflation Reduction Act Tax Credits 45V

In the United States, one of the most significant financial incentive mechanisms to stimulate the hydrogen economy is the Production Tax Credit for Clean Hydrogen, established under Section 45V of the Inflation Reduction Act (DOE, 2025b). This federal initiative accelerates clean hydrogen deployment by providing uncapped, direct tax credits to eligible producers for up to 10 years from the start of production. With the signing of the One Big Beautiful Bill Act (OBBBA) by President Trump, hydrogen producers must commence constructing projects by the end of 2027 to qualify for the credit. This represents a significant change from the original 2033 deadline (Corbeau & Hernandez, 2025)¹⁶. Compliance with the requirements is verified through mechanisms such as Renewable Energy Certificates (RECs). Oversight is provided by the U.S. Department of the Treasury and the Internal Revenue Service (IRS), ensuring that reported emissions, electricity sourcing, and labor compliance meet regulatory requirements (DOE, 2025a).

Sustainability Dimensions Covered (1) - GHG Emissions

The monetary value of the credit is directly linked to the greenhouse gas (GHG) emission intensity of the hydrogen production process, with a maximum of \$3.00 per kilogram of hydrogen for the lowest-emission tier. The credit system is structured into four tiers, each corresponding to a specific range of carbon intensity, as shown in Table 5.

TABLE 5: GHG EMISSION INTENSITIES TAX CREDITS (45V OF IRA)

GHG Emission Intensity (kgCO ₂ e/kg H ₂)	Production tax credit tier per kg of H ₂
< 0.45	US\$ 3.00
0.45 – 1.49	US\$ 1.00
1.5 – 2.49	US\$ 0.75
2.5 - 4	US\$ 0.6

Source: Eicke (2025)

The eligibility for each tier is assessed using a well-to-gate system boundary, capturing upstream emissions associated with hydrogen production (DOE, 2023a, p. 23).

¹⁶ Besides the adjustment to the forwarded required start-of-construction date of projects, and despite announcements suggesting a potential halt to funding for clean hydrogen initiatives earlier (Collins, 2025a), the hydrogen-related provisions under Section 45V of the Inflation Reduction Act (IRA) remain unchanged.

Section 45V adopts a technology-neutral approach, allowing all hydrogen production methods to qualify if specific criteria are met. For electrolytic hydrogen, from 2030 onward, electricity consumption must align hourly with renewable generation (monthly matching is allowed until then; ~ Temporal Matching). Power must also originate from the same grid region as the hydrogen facility (Deliverability ~ Geographical Correlation), and only new renewable electricity online within 36 months before hydrogen production counts toward eligibility (Incrementality ~ Additionality). Some exemptions apply (see, for example, Baker Botts, 2025).

The regulations extend tax credit eligibility to hydrogen produced from methane and natural gas alternatives, such as biomethane or fugitive emissions from coal mines or landfills, under specific conditions (DOE, 2025b). Under the IRA, carbon capture credits (45Q) are also available, and producers using natural gas alternatives must select one credit scheme (Shaw, 2025).

Sustainability Aspects Covered (2) - Prevailing Wage & Apprenticeship Requirements

To qualify for the full tax credit of up to \$3 per kilogram of clean hydrogen, projects must adhere to prevailing wage and apprenticeship standards. This ensures that workers involved in hydrogen production are paid fair wages and have access to training opportunities, fostering workforce development in the clean energy sector.

Projects must utilize a certain number of apprentices on projects, meeting three criteria:

- **Labor Hours:** A minimum percentage of total labor hours must be performed by apprentices (10% before 2023, 12.5% in 2023, and 15% from 2024 onwards).
- **Ratio:** The project must maintain the ratio of apprentices to workers who have completed their training set by the registered apprenticeship program.
- **Participation:** Any employer with 4 or more workers must hire at least one qualified apprentice.

All laborers and mechanics working on the project must be paid wages that meet or exceed the locally prevailing wage rates for their trade and geographic area. Essentially, the IRA aims to support skilled labor development through apprenticeship programs and ensure fair wages for all construction workers on qualifying projects (IRS, 2024).

Hydrogen-Specific vs. Generic

Section 45V specifically targets hydrogen deployment and decarbonization, setting detailed eligibility criteria for electrolytic, blue, and alternative methane-derived hydrogen.

Binding vs. Voluntary

The IRA Tax Credits are voluntary in nature; producers are not obligated to participate. However, for those who choose to apply for and receive the credits, compliance with the applicable requirements becomes mandatory. Failure to adhere to these requirements may lead to various consequences, including potential penalties and, in some cases, the revocation of the tax credits (IRS, 2024).

Scope

The tax credits consider the full hydrogen production value chain from feedstock acquisition through hydrogen generation, including upstream emissions for lifecycle GHG accounting. Electricity sourcing must align geographically with the hydrogen facility and meet temporal matching criteria. While the IRA applies within the United States, the requirements extend to imported feedstocks or energy used in hydrogen production if included in the well-to-gate emissions calculation.

4.5 Synthesis of Sustainability Governance in the U.S.

Tables 6 to 8 below provide a summary and comparative analysis of key U.S. regulations and initiatives concerning the sustainability of hydrogen, drawing on the categories outlined in chapter 2.6.

At the federal level, Biden-era legislation established a number of policies for the promotion of climate-friendly hydrogen technologies. Despite major changes to climate change policy

under the Trump administration, carbon-reduced hydrogen is in principle still incentivized financially through the IRA Section 45V tax credits, offering up to \$3 per kilogram of hydrogen produced. These incentives apply to different production pathways. Broader sustainability criteria are reflected in requirements to meet minimum apprenticeship targets and to comply with or exceed locally prevailing wage rates. However, projects must begin construction by the end of 2027, strongly reducing the scope of the measure.

The Clean Hydrogen Hub program also remains in place, although funding has been cancelled for two out of seven regions, and there is a substantial degree of uncertainty regarding the remaining hubs. Binding regulations are otherwise limited and largely confined to state-level instruments. Environmental justice considerations are partially integrated, notably in the Clean Hydrogen Hubs program.

At the regional level, targeted regulatory instruments remain in place. For example, California's Low Carbon Fuel Standard (LCFS) addresses climate-related sustainability, with a 2035 target to phase out non-renewable hydrogen. The LCFS is currently the only identified governance element that explicitly requires hydrogen to be renewable as a future compliance criterion.

Environmental protection for hydrogen at the federal level is indirectly governed, primarily through the National Environmental Policy Act (NEPA). Compliance with NEPA's Environmental Assessment process is, however, only required for projects receiving federal funding, requiring federal permits or approvals, led by federal agencies, or located on federal land. The current administration also dismantled the federal NEPA framework, leaving state authorities to follow their own procedures.

TABLE 6: REGULATION OF ECONOMIC ACTIVITIES IN THE U.S.

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Regulation of Economic Activities								
Clean Hydrogen Production Standard (CHPS)	X				Specific	Voluntary	GHG emission calculation methodology for domestic H ₂ production and establishment of emission threshold (4kgCO ₂ e/ kg H ₂)	
Regional Clean Hydrogen Hubs Program	X			X	Specific	Voluntary	Development of entire regional value chains across 5 regions in the US.	The CHPS is the guiding framework for the H2Hubs Program. Regardless, the DOE may select projects that do not fully meet the CHPS threshold, provided they “demonstrably aid the achievement” of the CHPS. Funding for two out of the former seven hubs was revoked, with five remaining hubs in place.
National Environmental Policy Act (NEPA)			X	(X)	Generic	Binding for certain cases	Applies to any federally funded infrastructure project, those requiring federal permits or approvals, projects led by federal agencies, or those located on federal land.	The NEPA process applies to major federal actions, such as projects receiving federal funding or requiring federal permits. Since the 2026 rescission of centralized CEQ oversight, the Department of Energy and other agencies now conduct reviews with their own procedures.
Low Carbon Fuels Standard (LCFS) California	X	X			Generic and Specific	Mostly binding	Directly for H ₂ as a fuel and indirectly as a feedstock for the production and import of low-carbon, hydrogen-based transportation fuels in California.	Binding for the majority of transportation fuel producers. Renewables-based fuels make it significantly easier to remain below the benchmark and earn credits. Gradual phase-out of non-renewable hydrogen.

Source: Authors

TABLE 7: TRANSPARENCY AND INFORMATION MECHANISMS IN THE U.S.

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Transparency & Disclosure Mechanisms								
California Transparency in Supply Chains Act				(X)	Generic	Partly Binding	Any company conducting business in CA with global revenues > \$100 million.	Mandates that certain companies subject to the Act must publicly disclose their efforts to address human trafficking and slavery in their supply chains

Source: Authors

TABLE 8: GOVERNMENT FUNDING SCHEMES IN THE U.S.

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary*	Scope	Remarks
Government Funding Scheme								
IRA 45V Tax Credits	X			(X)	Specific	Voluntary*	Domestic Hydrogen Production	Projects must begin construction by the end of 2027. Social Requirements refer to necessary adherence to prevailing wage standards and the employment of a minimum number of registered apprentices as eligibility requirements.

*Requirements are binding if projects want to be eligible and apply for funding through these mechanisms. Source: Authors

5 Sustainability Governance in China

This chapter presents the emerging hydrogen-related sustainability governance in China. Based on the framework presented in Chapter 2, it reviews strategies, policies, regulations and funding schemes in China that influence sustainability outcomes in the hydrogen sector. This includes both hydrogen-specific governance mechanisms and broader sustainability governance with implications for the hydrogen sector.

5.1 China's Hydrogen Strategy and Overarching Policy

Hydrogen was first recognized as a strategic emerging industry within China's 14th Five-Year National Development Plan (2021-2025). This prioritization is evident in China's dominance in electrolysis capacity (Collins, 2025b) and its drive to lead in fuel cells and fuel cell vehicles, supported by lower manufacturing costs (Gong & Quitzow, 2024). With 70% of crude oil and 40% of natural gas imported, energy security is a priority, and hydrogen offers a path to reduce this dependence. A third priority area focuses on the decarbonization of transport and heavy industries through the use of hydrogen (Yuxia & Fremery, 2025).

The draft of China's 15th Five-Year Plan, published in March 2026, further emphasizes the importance of the hydrogen sector. It is identified as a strategic "future industry" and a key driver of long-term industrial growth and resilience. The plan focuses on expanding production of hydrogen and its derivatives, i.e. green ammonia, green methanol, and sustainable aviation fuels, while promoting renewable-based production technologies despite current cost challenges. It also outlines integrating hydrogen production with local industrial hubs and zero-carbon industrial parks in resource-rich regions as a vehicle for creating a more connected energy-industrial ecosystem and for reducing renewable energy curtailment (Terzer, 2026).

China's Medium- and Long-Term Strategy for the Development of the Hydrogen Energy Industry (2021–2035) sets initial targets of 100,000–200,000 tonnes of renewable hydrogen annually by 2025, equivalent to 0.3–0.6% of the 33 Mt consumed in 2020 (Lou & Corbeau, 2023). While progress reports are limited, current developments suggest the target is on track despite weak offtake agreements (Eversheds Sutherland, 2025).

By 2050, hydrogen demand may reach 60 Mt, rising to over 130 Mt by 2060, accounting for approximately 20% of total end-use energy. In the near term, hydrogen production will rely on industrial by-products and coal-based sources, with a planned transition to renewable-based hydrogen in the medium to long term, leveraging the country's substantial renewable energy potential. Hydrogen production from natural gas with CCUS may be omitted from the transition pathway (Peng et al., 2024). The strategy also targets ~50,000 fuel-cell vehicles (FCVs) in 2025, increasing to 1 million by 2035, primarily in commercial transport such as buses and heavy trucks (Carbon Brief, 2022; Peng et al., 2024).

Notably, various Chinese provinces have published their own targets and strategies, often surpassing national targets. 18 of China's 34 provinces and regions have introduced individual renewable hydrogen plans, with Inner Mongolia aiming to produce 480,000 tons of renewable hydrogen by 2025 – more than double the national target of 2020 (Lou & Corbeau, 2023). Similar trends are observed in fuel-cell and fuel-cell vehicle targets.

5.2 Regulation of Economic Activities

Key Highlights for Hydrogen Sustainability

Green Low-Carbon Advanced Technology Demonstration (GLATD)

- State-owned enterprises are mandated to develop multiple components of the hydrogen value chain, even when projects are not financially viable.
- One GLATD category targets the deployment of up to 6 GW of electrolysis capacity.

Clean and Low-Carbon Hydrogen Evaluation Standard

- Defines a high-level terminology and GHG emission thresholds across different hydrogen production pathways.
- Demonstrates closer international alignment, with clear benchmarks: Renewable Hydrogen (≤ 2 kg CO₂e/kg H₂), Clean Hydrogen (≤ 3.86 kg), Low-Carbon Hydrogen (≤ 13.23 kg).
- Detailed implementation rules and launch timeline remain pending.

National Environmental Regulations

- Provide the legal basis for managing environmental risks in infrastructure development.
- Do not specifically require EIAs for hydrogen projects, though certain renewable electricity projects are covered.

China National Emissions Trading System (ETS)

- The world's largest ETS, covering companies emitting over 26,000 t CO₂e annually.
- No hydrogen-specific provisions, but the inclusion (2024) of ~3,500 firms in the power, steel, cement, and aluminum sectors incentivizes adoption of low-carbon technologies, including hydrogen.

Green Low-Carbon Advanced Technology Demonstration (GLATD)

GLATD is a strategic initiative coordinated by the Chinese government to accelerate the hydrogen economy and enhance technological leadership for China. It mobilizes state-owned enterprises (SOEs) to drive development in strategic sectors, including green hydrogen projects. These enterprises are required to implement green hydrogen projects even when not financially viable, effectively serving as an indirect subsidy backed by the state. Key participants include SINOPEC and China Energy Engineering Group Co. Ltd. (Dokso, 2025). While specific compliance mechanisms remain unclear, possible approaches may include adherence to the emerging national standard for green hydrogen pathways (see below).

Sustainability Dimensions Covered

China's Green Low-Carbon Advanced Technology Demonstration (GLATD) program focuses on greenhouse gas reduction by mandating state-owned enterprises (SOEs) to develop and utilize green hydrogen projects (Dokso, 2025). Announced in April 2025, the program aims to achieve up to 6 GW of electrolysis capacity among participating enterprises (Tengler, 2025).

Hydrogen-Specific vs. Generic

The program is hydrogen-specific in its scope, focusing on green hydrogen deployment, electrolysis capacity expansion, and associated infrastructure, although it also draws on experiences from broader advanced technology demonstration initiatives.

Binding vs. Voluntary

Participation in GLATD is mandatory for selected SOEs, effectively functioning as an indirect obligation. Non-compliance is mitigated through state oversight, ensuring that projects are implemented regardless of immediate commercial viability.

Scope

GLATD primarily addresses hydrogen production, particularly the deployment of electrolysis capacity, and promotes the broader development and utilization of green hydrogen. The program has a nationwide scope, aiming to establish approximately 6 GW of electrolysis capacity through SOE-led implementation. Available information focuses primarily on electrolysis capacity (Dokso, 2025; Tengler, 2025).

Clean and Low-Carbon Hydrogen Evaluation Standard

In July 2025, China released a draft Clean and Low-Carbon Hydrogen Evaluation Standard, introducing stricter lifecycle greenhouse gas (GHG) thresholds for hydrogen production. This framework represents a significant step toward harmonization with international benchmarks, particularly those of the EU (Tao, 2025). The standard (Standard No. DL/T 3015-2025, H2CN, 2026) was formally approved by the National Energy Administration (NEA) in December 2025 (NEA, 2025).

The standard provides detailed definitions, measurement methods, and reporting procedures for hydrogen producers and users, with oversight and potential enforcement by national authorities (Tao, 2025). Key details, however, such as exemptions, rules on temporal and geographical correlation, requirements for additionality, alongside specific compliance mechanisms, have not yet been disclosed.

Sustainability Dimensions Covered

The draft standard establishes a well-to-gate system boundary, accounting for emissions from raw material extraction, transportation, production, and on-site storage, minus CO₂ captured and permanently stored through carbon capture and storage (CCS). It provides clearer definitions for three categories of hydrogen (Tao, 2025)¹⁷:

- **Renewable Hydrogen:** ≤ 2 kg CO₂e/kg H₂, produced exclusively from renewable energy sources (specific methodological details remain pending). This threshold is more closely aligned with the EU's Renewable Fuels of Non-Biological Origin (RFNBO) limit of 3.38 kg CO₂e/kg H₂, which includes transport-related emissions.
- **Clean Hydrogen:** ≤ 3.86 kg CO₂e/kg H₂, applicable to any production pathway (detailed criteria not yet disclosed)
- **Low-Carbon Hydrogen:** ≤ 13.23 kg CO₂e/kg H₂, applicable to any production pathway (detailed criteria not yet disclosed).

Hydrogen-Specific vs. Generic

The overall scheme is hydrogen-specific, focusing on defining and categorizing hydrogen by its emission intensity and the source of energy.

Binding vs. Voluntary

Although not yet implemented, the standard may acquire binding status within China's broader carbon-neutrality framework. Compliance may become a prerequisite for participation in national incentive schemes and access to export markets. Given its early stage of development, uncertainties remain regarding its final scope and enforcement mechanisms. Still, the standard represents a shift from previous voluntary approaches to a more regulatory framework, aligned with international standards (Tao, 2025).

Scope

The standard applies nationwide and covers the entire hydrogen value chain up to the production gate, including feedstock extraction, energy inputs, and CCS activities. Though designed for domestic application, it is explicitly structured to align with international certification systems to facilitate global trade compatibility.

General Environmental Regulations in China

China's environmental regulatory framework is primarily anchored in the Environmental Impact Assessment (EIA) Law (first promulgated in 2002) and the Regulations on the Environmental Protection Management of Construction Projects, both of which aim to integrate environmental considerations into the planning and implementation of development projects.

Sustainability Dimensions Covered

The framework primarily addresses environmental protection, focusing on mitigating impacts on ecosystems, air, water, and land during infrastructure and industrial projects. While hydrogen is not explicitly covered, the framework ensures that major energy projects undergo environmental review, which can indirectly influence hydrogen production,

¹⁷ Note that the information presented in this study is based on the draft version of the standard. At the time of the study's publication, no information was available regarding any potential changes made in the final version of the standard.

storage, and infrastructure development (Dong et al., 2025; Gao, 2023). Broader sustainability considerations, such as water use, emissions, and land impacts, may also be indirectly managed through relevant environmental laws, including the Water Pollution Prevention and Control Law (MEE, 2017). As part of EIA processes induced by the EIA law, public engagement is mandatory, granting affected communities the right to provide comments and requiring that stakeholder concerns be duly considered (Gao, 2023).

Hydrogen-Specific vs. Generic

The EIA framework is generic, designed for broad infrastructure and industrial applications, without hydrogen-specific provisions. No information was available regarding the existence of hydrogen-specific guidelines or similar standards.

Binding vs. Voluntary

Currently, no hydrogen-specific criteria define when a project must undergo an EIA in China, but certain thresholds exist for other sectors. For example, in 2024, the Ministry of Ecology and Environment introduced regulations mandating that EIAs be conducted for wind and PV power projects with a capacity of 500MW, due to their potentially significant environmental impacts. Additionally, these projects must align with ecological zoning controls and planning-level EIA processes to ensure optimal site selection (Dong et al., 2025). Additionally, the National Climate Change Adaptation Strategy 2035, released in May 2022, states that all major infrastructure projects will undergo an EIA by 2035. Although hydrogen infrastructure is not explicitly mentioned, this requirement could potentially apply to hydrogen production and related energy projects (Sandalow et al., 2022). In summary, while hydrogen projects are not currently automatically required by law to undergo an EIA, this may change in the future.

Scope

The EIA framework primarily covers the project level, including site selection, construction, operational phases, as well as storage and distribution. The regulations apply nationwide, with additional provincial or local guidelines potentially affecting hydrogen projects in specific regions.

China National Emissions Trading System (ETS)

The Chinese national Emission Trading System was launched in 2021, and aims to control and gradually reduce CO₂ emissions in various sectors. It is the largest carbon market in the world, covering approximately 8 billion tCO₂, or over 60% of national emissions (ICAP, 2025).

Covered entities are required to establish monitoring plans and submit monthly emissions reports detailing fuel consumption, calorific value, carbon content, purchased electricity, production output, and other relevant parameters. Provincial ecological and environmental authorities verify reported GHG data.

Entities must surrender one allowance per ton of CO₂ emitted. Currently, allowances are allocated 100% freely based on emissions intensity benchmarks. The Interim Regulations foresee a gradual introduction of auctioning to enhance emissions reduction, although specific timelines are not yet confirmed. Companies may use offsetting credits under the Chinese Certified Emissions Reduction (CCER) scheme for up to 5% of emissions, with only centrally registered projects eligible from 2025 onwards (Lv & Stanway, 2024). Prior to the national ETS, similar regional programs operated in seven Chinese provinces.

The 2024 Interim Regulations for the Management of Carbon Emissions Trading provide the legal framework for enforcement and penalties. Non-reporting or fraudulent reporting results in fines ranging from CNY 500,000 (≈USD 69,500) up to ten times the value of any illegal gains. Failure to surrender required allowances triggers penalties of five to ten times the market value of the shortfall, and persistent non-compliance may lead to reductions in future allocations or suspension of production (ICAP, 2025).

Sustainability Dimensions Covered

The China National Emissions Trading System (ETS) primarily targets carbon dioxide (CO₂) emissions, with limited coverage of other greenhouse gases (ICAP, 2025).

Hydrogen-Specific vs. Generic

The ETS is a generic framework, covering major industrial sectors without hydrogen-specific provisions.

Binding vs. Voluntary

As of 2024, the ETS covers over 3,500 companies in the power, steel, cement, and aluminum sectors with annual emissions exceeding 26,000 tCO₂. Compliance is legally mandatory, with financial penalties and operational sanctions for non-compliance (ICAP, 2025).

Scope

The ETS primarily addresses direct emissions from production activities within covered sectors. It currently does not extend to indirect emissions from purchased electricity or upstream/downstream supply chain activities. Geographically, the system applies across all participating industrial facilities in China.

Region-Specific Sustainability Governance: The Example of Inner Mongolia

In China, national and regional approaches to hydrogen development vary. Notable regional governance measures were announced in various regions, including Inner Mongolia. In 2023, the regional government began differentiating between grid-connected and off-grid hydrogen production projects. Additionally, a notice from the Inner Mongolia Bureau of Energy specifies that “grid-connected projects, in principle, should not purchase electricity from the public grid,” and any grid-sourced electricity must not exceed 20% of the project’s total renewable power generation. Projects that entirely avoid grid electricity would align with the concept of temporal correlation, which requires renewable power generation and hydrogen production to occur simultaneously (Lou & Corbeau, 2023). However, these provisions remain in the form of preliminary notices, and their practical enforcement is still unclear.

5.3 Transparency and Disclosure Mechanisms

Key Highlights for Hydrogen Sustainability

Green Finance Taxonomy China

- Effective from 1 October 2025, the taxonomy requires all green debt issuers in China to report on alignment with its criteria.
- A range of hydrogen-related activities is eligible for classification as sustainable, provided they meet at least one environmental objective: (i) environmental protection, including pollution control and ecological conservation; (ii) climate change mitigation and adaptation; or (iii) efficient resource utilization, such as circular economy practices and waste recycling.
- Additional technical criteria and requirements also apply to ensure proper classification and reporting.

Corporate Sustainability Disclosure Standards (CSDS) China

- A mandatory ESG disclosure system is targeted for 2030, covering both listed and non-listed companies, large enterprises, and SMEs, for domestic operations of national and international firms.
- The standards will include multiple layers, starting with Basic Standards (some already published and aligned with the ISSB standards, but following a double-materiality approach)
- The framework will be complemented by sector-specific thematic standards and application guidelines, including hydrogen-related aspects, with draft climate disclosure standards already published.

Green Finance Taxonomy in China

The Chinese Green Finance Taxonomy was first operationalized in 2021, through the Green Bond Endorsed Project Catalogue (2021 Edition, PBoC et al., 2021), which was issued by the People’s Bank of China and other regulators. Effective since July 2021, it represented the country’s first comprehensive classification framework for environmentally sustainable projects and activities, though it applied exclusively to green bonds. In July 2025, the Green Finance Endorsed Projects Catalogue was published (2025 Edition, PBoC et al., 2025). This new taxonomy, taking effect from 1 October 2025, significantly broadens

the scope from bond-related activities to a unified framework for all green finance instruments, including green credit, bonds, funds, and insurance (Yue & Cheok, 2025).

Sustainability Dimensions Covered

The Taxonomy aims to channel financial resources toward economic activities that advance three core environmental objectives: (i) environmental protection (including pollution control and ecological conservation), (ii) climate change mitigation and adaptation, and (iii) efficient resource utilization (such as circular economy practices, waste recycling, and pollution prevention) – all as laid out in the Green Finance Endorsed Projects Catalogue (2025 Edition, PBoC et al., 2025). Within the Catalogue, activities are further distinguished by their type of environmental contribution, as indicated in the accompanying notes:

- Direct greenhouse gas (GHG) reduction: activities with absolute or relatively significant carbon emission reduction benefits.
- Enabling activities: those that do not directly reduce GHG emissions but create the conditions for mitigation (e.g., infrastructure, equipment, or service provision).
- Contributions to the other two environmental objectives: activities primarily to contribute to environmental protection and efficient resource utilization.

The Catalogue highlights climate relevance through a dedicated column indicating whether an activity contributes to GHG emission reductions.

To qualify as environmentally sustainable under the Chinese taxonomy, an activity must:

1. Be explicitly listed in the Catalogue;
2. Contribute to at least one of the three environmental objectives;
3. Comply with technical and regulatory criteria specified in the Catalogue and, where relevant, in the Green Industry Guiding Catalogue (2019 Edition);
4. Meet applicable national and local laws, regulations, and standards concerning product quality, safety, environmental protection, labor protection, occupational health, and industrial policy;

Unlike the EU taxonomy, China's framework does not feature explicit "Do No Significant Harm" criteria or minimum social safeguards. Instead, compliance with existing national regulatory requirements and technical standards is deemed sufficient to ensure quality, safety, and environmental integrity (ibid.).

Hydrogen-Specific vs. Generic

The catalogue includes various hydrogen-related use cases (see below), as well as indirect references through other technologies aimed at incentivizing the replacement of carbon-intensive products and fuels.

Binding vs. Voluntary

The 2025 Green Finance Endorsed Projects Catalogue became legally binding for onshore green debt issuers in China from its formal implementation on 1 October 2025. These issuers are required to ensure that any projects financed under green bonds, loans, or other eligible financial instruments are aligned with the taxonomy's criteria. They must also report publicly on the environmental performance of these projects, providing transparency to investors and regulatory authorities (Yue & Cheok, 2025).

Scope

The 2025 taxonomy identifies 271 eligible economic activities - within China - in the form of categories (Yue & Cheok, 2025), including several related to hydrogen. For example:

- **4.1.9 Hydrogen Energy 'Production, Storage, Transportation, and Utilization' Full-Chain Equipment Manufacturing:** encompassing the production of specialized components such as valves and plugs for hydrogen pressure vessels and pipelines. These are enabling activities that facilitate decarbonization but do not directly reduce emissions themselves.
- **4.2.8 Hydrogen Energy Infrastructure Construction and Operation:** covering facilities for renewable, nuclear, or biomass-based hydrogen production, as well as hydrogen storage, transportation, and refueling. These activities are categorized as providing direct carbon mitigation benefits (PBoC et al., 2025).

The taxonomy thus spans various parts of the hydrogen value chain, from production through infrastructure deployment, with a geographic scope focused on domestic activities in China.

Corporate Sustainability Disclosure Standards (CSDS) China

At the end of 2024, China's Ministry of Finance, together with eight other government bodies, issued the inaugural 'Corporate Sustainability Disclosure Standards (CSDS) – Basic Standards', also called Trial Standards (Glueck & Munzinger, 2025). This release marks a key step toward aiming to establish a unified national framework for ESG reporting.

Oversight is centralized at the national level, with phased implementation ensuring that reporting obligations are gradually expanded. Compliance will evolve from voluntary disclosure to mandatory reporting, with verification and assurance mechanisms expected to accompany quantitative ESG metrics as the framework matures. Enforcement is likely to involve regulatory review, potential penalties for non-compliance, and reputational consequences (Bakertilly, 2025).

Sustainability Dimensions Covered

The Corporate Sustainability Disclosure Standards (CSDS) in China are structured to comprehensively address Environmental, Social, and Governance (ESG) dimensions – following a double materiality approach (ibid.).

The government aims to introduce a complete national ESG disclosure system - including basic standards, specific thematic standards, and application guidelines - by 2027, with full nationwide implementation targeted for 2030 (Glueck & Munzinger, 2025).

The Trial Standards define overarching disclosure principles, concepts, and objectives, and require companies to build internal systems to ensure high-quality sustainability data collection and reporting. They emphasize the provision of material information on sustainability risks, opportunities, and impacts for decision-makers, applying what is broadly understood as a double-materiality approach. The Standards also set information-quality criteria, including relevance, comparability, verifiability, clarity, and timeliness. Disclosure requirements follow four core elements—governance, strategy, risk and opportunity management, and metrics and targets—closely aligning with the structure of international systems such as IFRS S1 (ibid., see also Chapter 8.2).

Complementing the basic standard, draft climate-specific standards have been released, modelled on IFRS S2 but adapted to Chinese regulatory and market conditions, including national carbon-accounting rules and the role of emissions trading (Glueck & Munzinger, 2025). Draft application guidelines have also been issued to clarify key concepts such as materiality, value-chain boundaries, proportionality, and the integration of financial impacts (ibid.). While the CSDS are broadly aligned with ISSB standards, they adopt a double materiality approach, in this aspect contrasting the ISSB standards, which focus primarily on financial materiality.

Hydrogen-Specific vs. Generic

The CSDS provide a generic framework applicable across sectors, including hydrogen production and consumption. While not hydrogen-specific, its principles are relevant to the hydrogen value chain, particularly regarding environmental impact assessments, emissions reporting, and social responsibility. The sector-specific application guidelines shall cover nine high-emission and strategic industries, including power, steel, cement, and, and also hydrogen. These are under development and will follow with the finalization of the climate standards (Glueck & Munzinger, 2025).

Binding vs. Voluntary

The adoption of the published Basic Standards is currently voluntary. Implementation is planned to progress in stages—expanding from listed to non-listed companies, from large enterprises to small and medium-sized enterprises, from primarily qualitative disclosures to quantitative metrics, and ultimately from voluntary to mandatory reporting (Glueck & Munzinger, 2025). By 2030, a fully unified national ESG disclosure system is aimed to be in place (Bakertilly, 2025; CNEUCN, n.d.).

Scope

The standards are expected to apply to all relevant corporate activities, covering upstream, operational, and downstream operations within the company's value chain. While currently focused on major domestic companies, the framework will eventually extend to smaller and non-listed enterprises. Once fully implemented, the CSDS will be subject to domestic operations of both national and international firms (Bakertilly, 2025).

5.4 Government Funding Schemes

Key Highlights for Hydrogen Sustainability

National Hydrogen Pilot Program

- Provides long-term, government-backed loans to support innovative hydrogen projects with substantial carbon mitigation potential across the hydrogen value chain.
- Renewable hydrogen projects are required to operate at a minimum 50%, employ electrolysis capacity of minimal 100 MW, and source no more than 20% of electricity from the grid, with the remainder derived from renewable energy.
- Fossil-based hydrogen production projects must integrate carbon capture and storage (CCS) technologies for emissions reduction to become eligible.

China's National Hydrogen Pilot Program

In June 2025, the National Energy Administration (NEA) launched a comprehensive nationwide hydrogen pilot program designed to accelerate the development and integration of hydrogen technologies across China's energy system. At its core, the program provides access to government-backed long-term loans and regional financial support for projects that meet specific technical and strategic criteria.

Eligibility for receiving the support is contingent upon meeting technical and operational criteria. Moreover, selection prioritizes projects that demonstrate technological innovation, novel business models, and substantial carbon mitigation potential. Preference is also given to initiatives that already possess the required permits, align with national R&D priorities, or employ pioneering technologies supported by strong commercial and technical foundations (FCW, 2025).

While the program emphasizes electrolytic hydrogen, detailed sustainability requirements and additional selection criteria remain publicly unavailable. Given the inclusion of multiple production pathways, projects may be expected to comply with the Clean and Low-Carbon Hydrogen Evaluation Standard, though this has not been confirmed.

Sustainability Dimensions Covered

The program outlines several sustainability dimensions as part of its framework. Among the various categories addressed, particular emphasis is placed on 'green' hydrogen. Eligible projects and their associated electrolysis capacities must exceed 100 MW, having an ongoing operating load of at least 50%, and may only source a maximum of 20% of their electricity from the grid (Martin, 2025a). The remainder of the electricity must originate from renewable energy sources (FCW, 2025), with more specific provisions about the characteristics absent. Other pilot categories include off-grid electrolysis in remote areas with capacities above 10 MW and hydrogen-based long-duration energy storage systems. To put this in context, the overall installed capacity in the entire EU of water electrolysis at the end of 2024 was 340 MW (IEA, 2025).

The pilot plan also includes hydrogen pathways using fossil-based primary energy integrated with carbon capture and storage (CCS), as well as coal-based electricity generation with defined hydrogen or ammonia blending ratios (FCW, 2025).

Hydrogen-Specific vs. Generic

The program is hydrogen-specific, targeting multiple stages of the hydrogen value chain, including production, storage, transportation, end-use applications, and integrated hydrogen hubs.

Binding vs. Voluntary

The Hydrogen Pilot Program is voluntary.

Scope

The initiative defines eleven categories of eligible projects: three in hydrogen production, two in storage and transportation, four in end-use applications, and two covering integrated hydrogen hubs and R&D (Martin, 2025a).

5.5 Synthesis of Sustainability Governance in China

Tables 9 to 11 below provide a summary and comparative analysis of key Chinese regulations and initiatives concerning the sustainability of hydrogen, drawing on the categories outlined in Chapter 2.6.

China's approach to hydrogen governance is shaped by the priorities of technological leadership, energy security, and decarbonization efforts, which remain at the forefront of national strategy. By 2025, it has become clear that the Chinese government is pursuing these objectives with considerable determination, underpinned by substantial state support. Recently, a strong commitment has become visible to promote renewable hydrogen. For instance, state-owned enterprises have been mandated to build up electrolysis capacity (up to 6 GW) within the framework of the Green Low-Carbon Advanced Technology Demonstration (GLATD) program, regardless of possible financial losses. In addition, the national hydrogen pilot program provides government-backed long-term loans. This includes funding for large-scale renewable hydrogen production projects of at least 100 MW electrolysis capacity. These should maintain an operating load of at least 50%, while only sourcing a maximum of 20% from the grid.

Alongside these industrial and strategic considerations, sustainability governance in the hydrogen sector—particularly with regard to greenhouse gas (GHG) emissions, international alignment, and once again, renewable hydrogen—has gained increasing prominence. A notable development in this context is the introduction of the Clean and Low-Carbon Hydrogen Evaluation Standards, which align more closely with the European Union's regulatory approach than earlier Chinese frameworks. Under these standards, the green hydrogen category establishes an emission benchmark of 2 kg CO₂e/ kg H₂ using renewable hydrogen, while the clean hydrogen category sets a threshold of 3.86 kg CO₂e/ kg H₂. Additionally, the trajectory now points more clearly toward a regulatory framework that is likely to move beyond voluntary compliance. Although the precise mechanisms of implementation remain uncertain, it is plausible that major government initiatives, including the GLATD program and the pilot loan scheme, will eventually be made conditional on adherence to these standards.

Moreover, China's policy developments exhibit points of convergence with international sustainability frameworks. Elements such as the Chinese Corporate Sustainability Disclosure Standards (CSDS) and Green Taxonomy exhibit similarities to EU mechanisms. Nevertheless, hydrogen-specific sustainability governance in China remains narrowly focused. Broader sustainability concerns—such as biodiversity, resource efficiency, social impacts, and others—are not substantively integrated into hydrogen-related governance and are instead addressed primarily through general environmental regulations. Social dimensions are not addressed within the current governance framework.

Overall, China's governance of hydrogen reflects an interplay between industrial strategy and emerging sustainability considerations. While the focus continues to lie on technological and security objectives, the gradual institutionalization of standards for low-carbon hydrogen suggests an incremental but notable shift towards sustainability governance that is more internationally harmonized.

TABLE 9: REGULATION OF ECONOMIC ACTIVITIES IN CHINA

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Regulation of Economic Activities								
Clean and Low-Carbon Hydrogen Evaluation Standard (Standard No. DL/T 3015-2025)	X	X			Specific	Yet to be determined	Domestic hydrogen production, potentially for export	Emission thresholds are more closely aligned with international standards, though exact implementation remains unclear to date. Renewable Hydrogen: ≤ 2 kg CO ₂ e/kg H ₂ , produced exclusively from renewable energy sources Clean Hydrogen: ≤ 3.86 kg CO ₂ e/kg H ₂ , applicable to any production pathway. Low-Carbon Hydrogen: ≤ 13.23 kg CO ₂ e/kg H ₂ , applicable to any production pathway.
General Environmental Regulations (e.g., EIA Law)			X	X	Generic	No	n/a	No hydrogen-specific environmental guidelines or mandatory requirements are currently in place (unlike for other renewables); stricter rules could evolve in the future
China's National Emissions Trading System (ETS)	X				Generic and specific	Partly	Domestic hydrogen and indirectly for hydrogen consumers (if above the overall emission threshold, see right column).	Mandatory for power-producing companies and industrial hydrogen users emitting >26,000 t CO ₂ annually
Green Low-Carbon Advanced Technology Demonstration (GLATD)	(X)	(X)			Specific	Yes	Mandates state-owned enterprises to develop green hydrogen projects in China.	Limited information is available regarding specific requirements, such as whether compliance with greenhouse gas emission standards is mandatory. The projects published to date encompass a range of different hydrogen production pathways

Source: Authors

TABLE 10: TRANSPARENCY AND INFORMATION MECHANISMS IN CHINA

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Transparency & Disclosure Mechanisms								
China Green Finance Taxonomy	X		X		Specific	Partly	Financial products that have investments in Hydrogen projects across the entire value chain domestically	Limited details on specific requirements; Hydrogen production shall contribute to reduce GHG emissions while avoiding harm to other environmental objectives.
Corporate Sustainability Disclosure Standards (CSDS)	X		X	X	Generic	Partly	Indirectly applicable to actors along the hydrogen value chain in China.	CSDS adopts a double materiality approach; sustainability coverage depends on material risks and the impact of a company's operations; mandatory initially for listed and large companies, extending to smaller/non-listed firms from 2030. Climate-focused standard available as a draft.

Source: Authors

TABLE 11: GOVERNMENT FUNDING SCHEMES IN CHINA

Sustainability Dimensions Covered								
Governance Instruments	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Scope	Remarks
Government Funding Schemes								
China's National Hydrogen Pilot Program	(X)	(X)			Specific		11 overarching categories throughout the domestic hydrogen value chain, with one category for electrolytic hydrogen	Little information on specific requirements was found, though compliance with the Clean and Low-Carbon Hydrogen Evaluation Standard may be required.

Source: Authors

6 Sustainability Requirements in Selected Government Funding Schemes

This section highlights selected government funding schemes and their sustainability requirements, outside the United States, European Union, and China, that are relevant to the global hydrogen economy. The focus is on examples that make notable contributions to hydrogen sustainability or play a significant international role, regardless of whether sustainability is explicitly embedded in national strategies or formal governance structures.

6.1 The H2Global Mechanism

Key Highlights for Hydrogen Sustainability

- The H2Global mechanism operates as a global market maker for hydrogen and hydrogen derivatives using a double-sided auction
- Sustainability requirements are linked to the priorities of governments who supply the funding for the various auction rounds.
- The latest auction, funded jointly by Germany and The Netherlands, adopts a comprehensive approach to sustainability, mandating RFNBO compliance, environmental protection, social contributions and procedural requirements.

The H2Global mechanism is a market creation instrument aiming to provide concrete business cases for producers and offtakers of hydrogen and its derivatives on a competitive basis and to actively support market development by providing liquidity and price-transparency. Core of the instrument is an intermediary trader, the Hydrogen Intermediary Trading Company - Hintco, that trades hydrogen and its derivatives via a double-auction mechanism (H2Global mechanism). The cost differences between cost of production and demand side are compensated by government support. To set up Hintco independent from Governments and Industry, Hintco is a 100% subsidiary of a non-profit foundation, the H2Global Foundation, and conducts the auctions independently.

The first auction round, completed in July 2024, awarded a contract to the renewable energy project developer Scatec ASA for the production of green ammonia in Egypt. The pilot tender was financed by the German Federal Government with €397 million. A second auction round, announced in February 2025, includes funding commitments of at least €2.5 billion from both the German and Dutch governments.

To be eligible for funding, project developers must demonstrate adherence to the requirements outlined in the Hydrogen Purchase Agreement. This includes both initial and periodic compliance verification, conducted by an approved Conformity Assessment Body (CAB) through structured audits. These assessments verify only the additional sustainability requirements and specific criteria; they do not constitute a separate certification scheme. Examples of CABs include TÜV and DNV. Hintco will maintain a list of eligible assessment bodies from which producers may choose. Additionally, to demonstrate compliance with EC-RFNBO requirements, a pre-certification from a voluntary scheme officially recognized by the European Commission is required (Hintco, n.d.).

Sustainability Dimensions Covered

Hintco does not impose uniform minimum environmental and social safeguards. Sustainability requirements within the H2Global mechanism are determined by the individual funding entities. The requirements are translated by Hintco into specific safeguards and become part of the Hydrogen Purchase Agreement (HPA), whose draft version becomes publicly available early in the process. This structure allows for flexibility across diverse

hydrogen production pathways and geographies. The first auction round (pilot tender) incorporated key sustainability criteria aligned with the principles of the EU RED. Additional sustainability considerations included restrictions on water use in water-stressed regions, the protection of high-biodiversity and carbon-rich lands through mandatory exclusion zones, and requirements for local value creation, such as workforce training and infrastructure development (NewClimate Institute, 2025). The requirements were expanded and detailed in the second and current auction round, as detailed in the following.

The draft Hydrogen Purchase Agreement (HPA), published as part of the tender documents, details key sustainability provisions primarily in Section 14 and the corresponding annexes. These include:

- **RED II Conformity:** Hydrogen must align with RED II/Delegated acts (RFNBO Hydrogen), utilizing only EC-recognized schemes for evidence.
- **Human Rights & Environmental Standards:** Applicants must comply with due diligence under existing supply chain laws (e.g., German Supply Chain Due Diligence Act, EU CSDDD) and conduct Environmental (EIA) and Social Impact Assessments (SIA). Environmental assessments should be aligned with either IFC Performance Standard 1 or World Bank Environmental and Social Standard (ESS) 1, while social assessments should follow IFC Performance Standard 1, SIA guidelines by the Roundtable for Sustainable Biomaterials, or World Bank ESS2. All assessment recommendations must be implemented. The HPA also requires adherence to various other international conventions on human rights and environmental protection.
- **Water Management:** Prohibition of utilizing fossil water or water intended for human consumption in areas with high or extremely high water stress (aligned with the World Resources Institute's country ranking). Monitoring of water stress impacts is required.
- **Seawater Desalination:** When desalinated seawater is used for the production of hydrogen, electricity for the desalination process must be sourced from renewable energy. Brine discharge into natural water bodies shall be avoided. However, if such discharge is unavoidable due to justified economic, technical, or regulatory reasons, brine management measures must be included in the EIA. If this leads to brine discharge, specific mitigation measures (Section 5.5 of Annex 14.1a) must be applied, including risks to local species listed as "vulnerable" or higher on the IUCN Red List.
- **Land Use:** Value chain installations must be located at least 1 km away from IUCN Category I–IV protected areas, UNESCO World Heritage Sites, and other areas with equivalent protection status.
- **Forced Settlement:** Prohibition of activities in areas with recent (within five years) forced settlements, requiring local authority confirmation of resettlement practices.
- **Biodiversity:** No activity may occur within 1 km of habitats occupied in the past year by endangered or critically endangered birds or mammals. Activities near a carbon stock must not release 1,000 tonnes or more of GHG, and any felled trees must be replaced with an equivalent number in the host country.
- **Local Value Creation:** Contributions to local training programs and infrastructure investments are required
- **Gender Equality:** Encouragement of gender pay equity and the appointment of equal opportunities officers in companies with 500+ employees.
- **Labor Standards:** Compliance with relevant ILO standards required, including those concerning the elimination of forced and compulsory labor (among others).
- **Environmental Management System:** Implementation of an ISO 14001:2015-compliant environmental management system.

Hintco retains the flexibility to accept alternative, yet equivalent, measures upon request by applicants.

Hydrogen-Specific vs. Generic

The auctions are currently tailored explicitly to hydrogen (and derivatives) projects. Eligibility, reporting, and compliance criteria are directly linked to hydrogen technologies, making the framework specific to this sector. Generally, and in future auctions, other products could be traded through the H2Global mechanism, if they contribute to decarbonization efforts and combating climate change.

Binding vs. Voluntary

Participation in the Hintco procedure is generally voluntary; however, all stipulated requirements and obligations must be adhered to. In the event of non-compliance or failure to meet these requirements, Hintco reserves the right to terminate the contract.

Scope

The H2Global mechanism acts as a global ‘Market-Maker’ targeting global production of renewable hydrogen and its derivatives. The inaugural auction focused on hydrogen production outside the European Union, with delivery to designated ports in Germany, the Netherlands, and Belgium. The second auction round is divided into five lots focused on hydrogen, ammonia, or methanol production (all in conformity with the EC’s definition of an RFNBO) from Africa, Asia, North America, South America (and Oceania), destined for delivery to Germany. A fifth lot allows for production globally (including Europe) for a delivery to either Germany or the Netherlands. In this fifth lot, the final product must be RFNBO-conform hydrogen (Hintco, 2025).

Agreements to provide future funds for using the H2Global mechanism have already been successfully established with Germany, the Netherlands, Canada, and Australia, while the Foundation also maintains collaborations with Austria, Belgium, Brazil, Denmark, India, Japan, Luxembourg, Norway, and Oman (H2Global Foundation, 2025). These efforts underscore the mechanism’s international reach and its potential role to support the development of a sustainable global hydrogen economy.

6.2 India’s Green Hydrogen Mission and Certification Scheme

Key Highlights for Hydrogen Sustainability

- India has developed a comprehensive hydrogen governance framework, encompassing substantial government funding, a Green Hydrogen Standard and National Certification Scheme.
- The government funding programme ‘Strategic Interventions for Green Hydrogen Transition (SIGHT)’ provides financial support, among other initiatives, to hydrogen production facilities. Projects receiving any state support must comply with the National Green Certification Scheme (GHCI).
- The GHCI has an ambitious threshold of 2 kg CO_{2e}/ kg H₂ (well-to-gate system boundary), using electrolysis through renewable energy sources or biomass conversion.

India is emerging as a central actor in the global hydrogen economy, supported by abundant renewable energy resources, strong industrial demand, and increasing policy momentum. Under the National Green Hydrogen Mission (NGHM), the government has articulated several key targets and enabling measures. These include achieving annual production of 5 million metric tonnes of green hydrogen by 2030, supported by the deployment of 15 GW of electrolysis capacity. It is pursuing a dual strategy that prioritizes domestic decarbonization while simultaneously developing substantial export capacity (MNRE, 2023a). To underpin market credibility and regulatory oversight, India has also established a dedicated governance architecture comprising the Green Hydrogen Standard and the Green Hydrogen Certification Scheme of India (GHCI), the latter launched in April 2025 (MNRE, 2025). In parallel, the government has introduced substantial public funding instruments for hydrogen deployment, linked to sustainability requirements under the GHCI.

Specifically, two funding categories have been launched as part of the programme ‘Strategic Interventions for Green Hydrogen Transition (SIGHT)’. The first category supports domestic production of electrolyzers, while the second provides incentives to support the production of green hydrogen. The latter targets early-stage projects and provides incentives to early movers in the sector. The initial budget for green hydrogen production is allocated at 13,050 crore (~\$1.47 billion USD) (MNRE, 2023b). Funds are disbursed through a transparent bidding process. The Ministry of New & Renewable Energy (MNRE) delegated the implementation of this funding scheme to the Solar Energy Corporation of India (ibid.).

Sustainability Dimensions Covered

Eligibility under the SIGHT production incentive scheme requires compliance with the National Green Hydrogen Standard; Compliance must be demonstrated through certification under the GHCI (MNRE, 2025, Section 14.6.1).

Specifically, the GHCI operationalizes the requirements of the Green Hydrogen Standard for India, which defines green hydrogen as hydrogen produced from renewable energy via

electrolysis or biomass conversion (MNRE, 2023c). GHG emissions from production and input materials—including water treatment, electrolysis, gas purification, drying, and compression—must not exceed 2 kg CO₂e per kg H₂, averaged over a 12-month period. This requirement applies equally to biomass-based hydrogen and reflects a well-to-gate system boundary. These requirements are operationalized in the GHCI, established in April 2025 (MNRE, 2025).

Beyond this emissions criterion, the SIGHT scheme does not impose broader environmental or social sustainability requirements. However, project developers must obtain all relevant governmental and local clearances, including environmental approvals, and submit quarterly progress reports on project implementation (SECI, 2023).

Hydrogen-Specific vs. Generic

The SIGHT incentive scheme, the Green Hydrogen Standard, and the GHCI are hydrogen-specific policy instruments.

Voluntary vs. Binding

In India, green hydrogen producers with annual production exceeding 10 tonnes that receive any incentive, subsidy, concession or exemption from the Government of India, including under the SIGHT scheme, are required to obtain a final certificate under the GHCI (MNRE, 2025, 14.6.1)¹⁸. Such a final certificate is also required if hydrogen is intended to be marketed as “green” hydrogen domestically. However, certification is not mandatory if the entire hydrogen production is designated exclusively for export. Producers are nonetheless required to report the volume and emissions of the hydrogen produced in line with the standards of the importing country (ibid.).

Scope

India’s Green Hydrogen Mission, along with the Green Hydrogen Certification Scheme and the SIGHT funding scheme, primarily target the production of green hydrogen for domestic consumption. Even if part of the hydrogen is intended for export, certification of the entire production volume through the GHCI is required (ibid.).

6.3 Brazil’s Low Carbon Hydrogen Development Program (PHBC)

Key Highlights for Hydrogen Sustainability

- Brazil’s Low Carbon Hydrogen Development Program (PHBC) is tax credit program designed to bridge the price gap between low-carbon hydrogen and conventional alternatives.
- Carbon Intensity: Eligibility is defined by a technology-neutral threshold of 7 kg CO₂e/ kg H₂, likely to be verified through the Brazilian Hydrogen Certification System (under development). The relatively high threshold enables the inclusion of bio-based hydrogen production pathways.
- Priority is given to projects demonstrating a higher potential to achieve lower emissions and to those capable of significantly reinforcing the national value chain.

Brazil is positioning itself as a strategic player in the global hydrogen economy, leveraging abundant renewable resources and a robust industrial base. The National Low-Carbon Hydrogen Policy (Law No. 14,948/2024) serves as the overarching legislative framework, encompassing the National Hydrogen Program (PNH2), the Special Incentive Regime (Rehido), and the Low-Carbon Hydrogen Development Program (Programa de Desenvolvimento do Hidrogênio de Baixa Emissão de Carbono – PHBC). Brazil’s hydrogen policy is complemented by the broader framework of the Brazilian Greenhouse Gas Emissions Trading System (SBCE). Applying a cap-and-trade mechanism, the SBCE establishes a domestic carbon price and a standardized verification system for large GHG emitters. This

¹⁸ Note that the certification process comprises multiple stages and issues specific certificate types, including, for example, a concept certificate and a provisional certificate, both of which are voluntary (MNRE, 2025, Sections 14.2–14.5). A concept certificate confirms that *the design* of the green hydrogen production facility meets the prerequisites and technical requirements of the certification scheme. A provisional certificate is automatically generated upon a producer’s application, based on submitted production and emissions data. It indicates that the hydrogen produced during a specified period qualifies as “green”, but is issued without verification by the Accredited Verification Agencies (ACVs).

ensures that carbon revenues are retained within Brazil and provide the legal proof of emissions required to mitigate border taxes, such as the EU's Carbon Border Adjustment Mechanism (INETTT & E+ Energy Transition Institute, 2026).

The PHBC, the largest funding programme, is a tax credit mechanism for low-carbon hydrogen projects. It allocates R\$18.3 billion (~ US\$3.36 Bn) over five years (2028 – 2032) through an auction-based system (Mattos Filho, 2024). The credits may cover up to 100% of the difference between the estimated cost of low-carbon hydrogen and the conventional products it replaces, directly tied to the carbon intensity of the produced hydrogen (Article 3, §1-2, L14,990).

Sustainability Dimensions Covered – Climate (1)

The PHBC (established through Law No. 14,990) sets out rules for providing tax credits for “low-carbon hydrogen”. While the law does not state specific emission limits, it is interconnected with the overarching hydrogen policy (Law No. 14,948), which defines a specific emission threshold for low-carbon hydrogen. Under this framework, hydrogen is classified as low-carbon if its carbon intensity does not exceed 7 kg CO₂ e/ kg H₂, regardless of the production pathway (Article 4 (XII) of the law, PR/CC/SAJ, 2024a).¹⁹ Compliance with the threshold is reinforced as participation is limited to beneficiaries of the Rehidro tax incentive scheme (Art. 4, §9, Law 14,990), which also requires adherence to the low-carbon threshold.

Compliance may be demonstrated through the Brazilian Hydrogen Certification System (SBCH2, Article 15, L14,948, PR/CC/SAJ, 2024a). However, detailed implementing regulations for the PHBC and the certification scheme are still under development. Although the Ministry of Mines and Energy announced a decree to provide clarifications and details in November 2025, these remain unpublished until publication of this study (End of February, MME, 2025).

Initially, political discussions set a threshold of 4 kg CO₂-equivalent per kilogram of produced hydrogen. The subsequent increase to 7 kg in the final policy appears to enable hydrogen produced via biomass pathways, such as ethanol, to qualify for subsidy programs (Collins, 2024). Generally, Brazil has extensive experience and a long-standing industrial history in the bioenergy sector, which may contribute to the Brazilian PtX Market (Agora Industry et al., 2024).

Sustainability Dimensions Covered – Other (2)

In addition to the carbon intensity threshold, PHBC sets out the following funding criteria: support for climate change mitigation and adaptation, contribution to regional development, promotion of technological development and diffusion, or contribution to the diversification of Brazil's industrial base (Article 3, §4, L14,990). Priority is given to projects that have the lowest potential GHG emission intensity and that have greater potential to strengthen the national value chain, as reflected in the remaining three requirements (Art. 4, § 11, Point II, L14,990). Once again, the decree announced in November 2025 (see above) may provide further clarification.

Hydrogen-Specific vs. Generic

The PHBC is specific to hydrogen and its derivatives.

Binding vs. Voluntary

Participation in the tax credit mechanism is voluntary.

Scope

The PHBC targets the production stage of hydrogen for domestic consumption in Brazil. Hydrogen derivatives are also eligible; however, the government has not yet specified which derivatives qualify for support. Tax credits are awarded to actors producing or buying low-carbon hydrogen (Article 4, §6, L14,990).

¹⁹ It might be noted that law L14,948 also features and describes other hydrogen pathways. As such, renewable hydrogen is hydrogen that meets this emissions threshold of low-carbon hydrogen, and that is either extracted as naturally occurring hydrogen or produced from renewable sources, including bio-based feedstocks, or through electrolysis powered by renewable energy sources such as solar, wind, hydropower, geothermal energy, or biomass. In addition, hydrogen may also be labelled green hydrogen if produced specifically through the electrolysis of water using renewable energy sources.

7 Standards and Certification Schemes

This chapter addresses standards and certification schemes. It first examines those that take a broader approach to sustainability, covering various sustainability dimensions (Chapter 7.1). This is followed by an overview of standards and certification schemes specifically focused on GHG emissions and decarbonization efforts (Chapter 7.2).

7.1 Sustainability-related Standards and Certification Schemes

Key Highlights for Hydrogen Sustainability

Sustainability-Related Standards

- Standards, including those defining sustainability requirements and performance specifications, are a central component of quality infrastructure, supporting transparency, comparability, and credibility across the hydrogen value chain.
- Internationally, the only document from a national standardization body that addresses sustainability from a holistic perspective is the German Institute for Standardization's (DIN) DIN 35809:2025-09, which is available as a draft. It covers 19 sustainability aspects, categorized into environmental, social, governance, and economic dimensions.
- It provides principles, criteria, and indicators for 19 sustainability aspects.
- The standard does not establish thresholds or benchmarks but utilizes a materiality assessment to evaluate the relevance and significance of individual sustainability aspects.

Sustainability-Related Certification Schemes

- Certification of sustainability-related criteria is a critical component of quality infrastructure, yet uptake in the hydrogen sector remains limited to date.
- A limited number of voluntary certification schemes currently focus specifically on hydrogen production and incorporate broader sustainability dimensions such as renewability, climate aspects, environmental safeguards, and social criteria.
- The most comprehensive in terms of sustainability coverage are the Green Hydrogen Standard (and its associated certification) and the Global Fuels Certification developed by the Roundtable on Sustainable Biomaterials (RSB).
- The CertHiLac initiative for Latin America and the Caribbean—although still under development—represents a noteworthy emerging framework, which aims to align both with international market requirements and the export priorities of LAC countries.

DIN 35809:2025-09 (Draft): Sustainability Criteria for Hydrogen and Hydrogen Derivatives

The German Institute for Standardization (DIN, 2024) has established a working group dedicated to developing a comprehensive sustainability standard. A draft standard (DIN 35809) encompassing broader sustainability criteria was published in September 2025 for a public consultation period. This represents the only national-level initiative explicitly aimed at creating a formal standard that integrates wider sustainability requirements and approaches. The DIN standard may inform the development of a future international standard for hydrogen sustainability.

Sustainability Dimensions Covered

The draft standard covers 19 sustainability aspects, categorized into principles (desired goals), criteria (requirements to be assessed), and indicators (measurable variables). The standard does not set specific thresholds or benchmarks for these criteria. A materiality assessment is used to determine whether a particular sustainability aspect is relevant and significant to the specific context. If an aspect is deemed irrelevant and/or not significant, no detailed assessment is required for that aspect.

The 19 sustainability aspects are organized across four categories:

- **Governance:** Non-discrimination and equal opportunities, stakeholder inclusion, transparency and accountability, anti-corruption, grievance mechanism
- **Environmental:** GHG emissions²⁰, water use, land use, biodiversity, waste, pollutants, energy efficiency, energy intensity
- **Social:** Human rights, labor rights, land and water rights
- **Economic:** Economic and financial viability, local economic development, energy supply

Each of these categories is subdivided into specific principles, criteria, and indicators, providing a comprehensive framework for evaluating the sustainability of hydrogen production and its supply chain. Based on the example of biodiversity, Box 6 illustrates how the draft standard operationalizes a sustainability aspect.

Box 6: Example of a sustainability aspect in DIN 35809:2025: Biodiversity

Biodiversity is one of the environmental aspects covered by the draft standard. The principle for biodiversity is to enhance biodiversity and reduce negative impacts. Regarding this aspect, various criteria are detailed, for example, one to avoid activities in protected areas and biodiversity hotspots. For this, various indicators exist:

- The business must avoid locating facilities within protected areas and key biodiversity areas.
- The business must document the location of parts of designated protected areas and key biodiversity areas affected by its operations, both directly and indirectly.
- The business must document the impact of its activities on biodiversity goals prescribed by the relevant authorities for the protected areas and on the directly affected environment (whether positive or negative).
- The business must document any permits obtained from the relevant authorities for activities conducted within protected areas.
- The business must document the effects of its activities on the key biodiversity features of impacted key biodiversity areas and the directly affected environment (whether positive or negative).

Other criteria include that the business selects sites for facilities within the value chain in such a way that negative impacts on biodiversity are minimized and that this minimization is also applied during the operation of the facilities, each with specific indicators.

Hydrogen-Specific vs. Generic

The standard applies specifically to hydrogen and hydrogen derivatives, including ammonia, methanol, and liquid organic hydrogen carriers (LOHC).

Binding vs. Voluntary

This draft standard is not binding in nature. As it does not set any thresholds or benchmarks, it would not be suitable for adoption as a binding regulatory standard without further modification.

Scope

The standard covers the entire hydrogen value chain, from production (including inputs like water, energy carriers, and land) to conditioning, conversion, storage, up to the delivery to end-users. Outputs, such as waste, are included, but the product's use is not covered by the standard.

As the standard does not set specific thresholds, it could be applied across various jurisdictions worldwide, where different rules apply.

²⁰ The standard does not prescribe a specific emission threshold but states that the amount of emission shall not exceed a given threshold in the relevant market. Different emission calculations can be used, e.g., DIN EN ISO 14067:2019-02, ISO/DIS 19870-1:2025, and others.

Green Hydrogen Standard (Green Hydrogen Organisation)

The Green Hydrogen Standard 2.0, published in December 2023 by the Green Hydrogen Organisation (GH₂), outlines a framework for assessing the sustainability of hydrogen production (GH₂, 2023b). Project developers may apply for voluntary certification to demonstrate compliance, enabling the use of the 'GH₂ Green Hydrogen' label, which also covers green ammonia, methanol, and synthetic methane.

Beyond certification, the Green Hydrogen Organisation is actively engaged in a wide range of initiatives, including the dissemination of informational materials, publications, and the organization of dialogues and events among diverse stakeholders. A notable example is the Green Hydrogen Charter, which brings together governments to share best practices and policies supporting the growth of the global green hydrogen economy. In that context, GH₂ has launched regional platforms in India, China, the wider APAC region, and African countries, fostering international collaboration and knowledge exchange (GH₂, n.d.).

Sustainability Dimensions Covered

The Standard (GH₂, 2023b), drawing from a variety of existing mechanisms, including the IFC Performance Standards, defines seven principal certification requirements across three tiers, each comprising various sub-requirements. These tiers include mandatory requirements (which must be fulfilled), expected requirements (for which justified and documented exceptions may be permitted), and optional requirements (which are encouraged but not compulsory).

Requirements in detail (extract):

- **Strategic Alignment (Requirement 1; mandatory):** Projects must demonstrate alignment with host country policies, national plans, and the UN SDGs. This is evidenced through a comprehensive assessment of environmental, social, and economic impacts, along with mitigation plans.
- **Stakeholder Engagement & Regulatory Compliance (Requirement 2; mandatory):** Projects must demonstrate adherence to national laws and regulations through a proper approval process, with established channels for risk management and stakeholder engagement.
- **Optimized Project Design (Requirement 3; mandatory):** Project location and design must be optimized through an iterative and consultative process, addressing key technical, economic, financial, environmental, and social considerations. To demonstrate compliance, an evaluation report must be made publicly available.
- **Energy source & GHG Emissions (Requirements 5A, 5E; mandatory, expected, and optional aspects):** Hydrogen must be produced via water electrolysis powered by (nearly) 100% renewable electricity. Eligible sources include hydropower, wind, solar, geothermal, and ocean energy. Where grid electricity is used, power purchase agreements with renewable operators must cover at least the equivalent amount of electricity claimed. Temporal and geographical matching requirements are expected to be considered (no specific characteristics detailed). Limited use (up to 5%) of non-renewable electricity is permissible under specific technical or market constraints. The overall GHG emission threshold as a mandatory criterion is set at a maximum of 1 kg CO₂/kg H₂ in one calendar year (well-to-gate). Developers are encouraged to account for additional GHG emissions from construction, storage, conversion, and delivery infrastructure.
- **Additional Requirements for Environmental Impacts (Requirements 5, 5B; mandatory and expected aspects):** An Environmental Impact Assessment is expected to be carried out. Projects must conduct a water utilization and pollution evaluation, with a management plan in place. It is mandatory to demonstrate that desalination plants do not adversely affect water sources, as well as to identify and monitor any associated biodiversity impacts
- **Social Impact & Human Rights (Requirements 4, 4A-E; mandatory, expected, and optional aspects):**

Mandatory requirements: Project operators must avoid involuntary resettlement wherever possible, provide fair compensation and improvements to living conditions if displacement occurs, identify and mitigate human rights impacts, and ensure access to effective grievance mechanisms.

Expected actions: Projects are expected to engage affected communities using local knowledge, conduct a social impact assessment, plan for continuous improvement, maximize local development opportunities, and involve smaller businesses in the supply chain.

Optional elements: Project operators are encouraged to align with the IFC Performance Standards on workers' organizations and collective bargaining.

- Additional local value through increased electricity and water capacity (Requirements 5A, 5B; expected and optional aspects): A certification expects a project developer to have identified and implemented technically feasible and cost-effective measures to support the expansion of renewable energy capacity. Furthermore, the mandatory water strategies may include (optional) an assessment of opportunities to deliver co-benefits to local communities, such as providing drinking water, irrigation water, and/or water treatment services.
- Governance, Transparency & Accountability (Mandatory): Projects must establish codes of conduct and anti-corruption standards, with disclosure of key corporate and financial information.

GH₂ also offers a pre-qualification process for projects prior to financial closure, assessing ESG aspects to support investor and stakeholder engagement (GH₂, 2023a).

Hydrogen-Specific vs. Generic

The standard is specifically designed for hydrogen and derivatives.

Binding vs. Voluntary

Project developers may apply for voluntary certification to demonstrate compliance, enabling the use of the 'GH₂ Green Hydrogen' label. The overall process includes stakeholder consultation, the preparation of a draft report for public consultation, and the submission of a final report to GH₂'s Accreditation Body. To ensure ongoing compliance, GH₂ conducts risk-based spot checks as well as periodic reviews of accredited projects (GH₂, 2023b).

The tiered approach of the Standard, with its emphasis on both mandatory and voluntary elements, incentivizes outstanding performance and ambition to promote a sustainable hydrogen economy. As of mid-March 2026, no hydrogen or derivatives project has been certified with the GH₂ label.

Scope

The Green Hydrogen Standard addresses the production of hydrogen, ammonia, methanol, and synthetic methane. It shall serve as a global minimum benchmark, providing national governments with a reference point for developing and refining national and regional standards for green hydrogen (GH₂, 2022b).

Roundtable on Sustainable Biomaterials: Global Fuels Certification

The Roundtable on Sustainable Biomaterials (RSB) is a non-profit organization promoting a sustainable bio-based and circular economy through international networks, programs, and certification schemes focused on biomaterials and climate solutions. RSB is a code-compliant member of ISEAL (2023b), and its certification system is underpinned by a comprehensive set of principles, criteria, and requirements, which outline best practices across legal, environmental, social, and management practices (RSB, 2023b).

For hydrogen and its derivatives, RSB offers the Global Fuels Certification (based on the RSB Standard for Advanced Fuels; RSB, 2023b) for worldwide coverage and the EU RED Fuel Certification for Europe, the latter currently under review by the European Commission for voluntary RED II compliance recognition.

RSB differentiates between various levels of bindingness within its schemes: mandatory requirements, recommended actions considered most suitable without excluding alternatives, permissible actions, and, finally, actions presented as guidance or optional measures (RSB, 2023c; p. 3).

The following sections refer to the Global Fuels Certification, which is similar to the EU-focused certification.

Sustainability Dimensions Covered (1) – Climate and Renewability Aspects

Under the RSB Global Fuels Certification, the following hydrogen-related categories of products are eligible for certification: renewable hydrogen produced via electrolysis using renewable electricity, from biomass, or through the reforming of renewable fuels; electro-fuels (e-fuels), defined as liquid or gaseous fuels synthesized from renewable hydrogen in combination with CO/CO₂ or nitrogen sourced from biological or non-biological processes; and RFNBOs (Renewable Fuels of Non-Biological Origin), which are hydrogen-based fuels

that meet renewable criteria but do not currently fall under EU RED recognition²¹. Fossil-based hydrogen is explicitly excluded from certification.

All RSB-certified hydrogen products must be produced using electrolytic hydrogen and renewable energy, with additionality demonstrated within 36 months and renewable generation aligned on a monthly basis (or sourced from stored electricity) with production. A strict geographical correlation is not required under the RSB Global Fuels Certification; however, operators must demonstrate that their electricity sourcing does not create a risk of grid congestion. The same requirements apply to electricity used for water desalination, if applicable (RSB, 2023b, p. 30 -33).

All three must achieve a GHG emission intensity of ≤ 3.4 kg CO₂e/kg H₂ (well-to-wheel, as stated in the RSB Standard for Advanced Fuels, p.34). Notably, the certification supports 'free allocation', allowing producers using both renewable and non-renewable energy to assign the renewable share to RFNBO-output (or renewable hydrogen and e-fuels), while allocating the non-renewable share to non-RFNBO output. This flexibility distinguishes RSB Global Fuels from the EU RED Fuel Certification, which does not allow such allocation. As of April 2025, only one producer was undergoing certification (note that several SAF producers have already been certified; see the RSB database; RSB, n.d.).

Sustainability Dimensions Covered (2) – Broader Sustainability Aspects

Besides the above-described requirements towards climate and renewability, the criteria from the following 10 (out of 12 in total) RSB's sustainability principles apply (RSB, 2023b):

- **Principle 1 (Legality - mandatory):** Operations must comply with all relevant national and international laws, including those related to social and environmental issues.
- **Principle 2 (Planning and Monitoring - mandatory):** Requires participatory planning processes and environmental and social impact assessments, ensuring stakeholder engagement that is gender-sensitive, consensus-driven, and inclusive of vulnerable groups. Free, Prior, and Informed Consent (FPIC) and grievance mechanisms are also required. For impact assessments, RSB has developed its own guidelines (RSB Impact Assessment Guidelines), which partly refer to the IFC Performance Standards for compliance.
- **Principle 3 (GHG Emissions - mandatory):** For hydrogen-related activities, specific requirements differ slightly from the original Principle 3; specifics as described below.
- **Principle 4 (Human and Labour Rights - mandatory):** Ensure all workers' human and labor rights are respected, including freedom of association, absence of forced or child labor, non-discrimination, fair wages and working conditions, occupational health and safety, and access to grievance mechanisms.
- **Principle 5 (Rural and Social Development - mandatory):** Projects in areas of poverty must improve local livelihoods through employment, skills training, and local partnerships, with emphasis on women, youth, and Indigenous peoples
- **Principle 7 (Conservation of biodiversity and ecosystems - mandatory):** Land conversion requires value screening; operations are prohibited in protected areas, ecological corridors must be maintained, and renewable electricity must not originate from 'no-go' or conservation areas since 2008
- **Principle 9 (Water - mandatory):** Water use must not jeopardize community access or deplete water resources. Disputed water sources cannot be used until resolved through an FPIC-based negotiation. A water management plan is required.
- **Principle 10 (Air Quality - mandatory):** Air pollution must be minimized throughout the supply chain.
- **Principle 11 (Waste Mgmt. - mandatory):** Ensure responsible use of technology and inputs by minimizing environmental and social risks, containing hazardous organisms, safely managing chemicals and residues, and promoting technologies that improve long-term social and environmental performance.
- **Principle 12 (Land Rights - mandatory):** Land use must respect legal and customary rights. Disputed land cannot be used until resolved through FPIC. Involuntary resettlement is prohibited, and fair compensation is required for voluntary land transfers, based on independent valuation.

The described criteria are generally all mandatory, but their binding nature varies in terms of how their specific requirements are achieved. For example, regular working hours must not exceed 48 per week (principle 4), while overtime – when voluntary - is allowed up to a total of 80 hours per week. Recommendations for overtime handling include limiting it to

²¹ Note that, if a fuel or feedstock is intended for the EU market under the EU's regulatory framework, the RSB EU RED Fuel Certification may apply.

short periods, providing adequate compensation and rest, agreeing through collective bargaining, and having third-party ratification (RSB, 2023b).

RSB provides extensive guidance, including screening methodologies and social impact assessment tools, aligning with global best practices in sustainability certification. Similar to the Green Hydrogen Organisation, RSB functions as a comprehensive platform advancing sustainable biofuels and hydrogen globally.

Hydrogen-Specific vs. Generic

The certification scheme is specifically designed for hydrogen and derivatives.

Binding vs. Voluntary

It is a voluntary scheme applied to fuels produced anywhere in the world.

Scope

The RSB Global Fuels Certification addresses the production of hydrogen, synthetic fuels based on renewable hydrogen, or RFNBOs produced not for the EU-regulated market.

Climate Bonds Standard and Certification Scheme (Climate Bonds Initiative)

The Climate Bonds Initiative (CBI) is an international non-profit organization dedicated to mobilizing global capital for climate action. Funded by public donors including development banks, foundations, and commercial/investment banks, CBI has developed the Climate Bonds Standard and Certification Scheme – a labeling scheme initially designed for a variety of financial instruments such as bonds, but now extended to also certify production assets directly, across a range of sectors including agricultural production, bioenergy, cement, low carbon transport, steel, solar energy, and hydrogen production (CBI, 2025).

Beyond certification, CBI actively engages in dialogue, research, and capacity building, including the Climate Bonds Resilience Taxonomy, Climate Finance Solutions, and Transition Finance initiatives. Notably, CBI has been a significant contributor to the development of the EU Sustainable Finance Taxonomy, demonstrating its role extends far beyond a simple certification scheme (CBI, n.d.).

Sustainability Dimensions Covered (1) – Climate Aspects

Beyond the overarching standard, CBI offers a hydrogen-specific framework - the 'Hydrogen Eligibility Criteria of the Climate Bonds Standard & Certification Scheme' (CBI, 2023).

Therein, it is stated, that for electrolytic hydrogen production, certification requires GHG emissions of ≤ 3.0 kg CO₂e/kg H₂, decreasing to 1.5 in 2030, 0.7 in 2040, and ultimately “close to net-zero” by 2050 (CBI, 2023, p. 17), using a well-to-consumption approach (ibid., p. 18). Renewable electricity must be temporally correlated, monthly until 2029, hourly from 2030, with locally stored electricity permitted. Geographic correlation requires demonstrating the capacity to transport renewable electricity from source to site, avoiding grid congestion. Additionality requires the renewable power plant to start operation with or after the electrolysis, via direct connection, a PPA, or curtailed surplus electricity; this requirement is waived for grid balancing or low-capacity operation, and temporal and geographic correlation are not needed for direct connections.

The same GHG thresholds apply to hydrogen produced from fossil fuels with CCU or CCS, but facilities starting after 2035 are ineligible for certification. Methane emissions must be monitored, reported, and verified, with $\geq 90\%$ capture for process and combustion. CO₂ transport losses must be $< 0.5\%$, and CO₂ utilization is limited to durable products such as polymers or construction materials. An Environmental Impact Assessment, consistent with local regulations and conducted by an independent third party, is required. This must include air pollution prevention measures, assessment of potential impacts on water resources (including a Water Management Plan), and necessary water usage licenses. For desalination, a Brine Management Plan addressing potential environmental risks is also required.

Sustainability Dimensions Covered (2) - Adaptation and Resilience Criteria

CBI includes adaptation and resilience criteria (CBI, 2023, p. 15) requiring hydrogen producers to disclose potential environmental and social impacts of their facilities, including electricity use, water, biodiversity, and effects on neighboring properties. Applicants must

describe risk management strategies and monitoring systems to demonstrate climate resilience. These criteria serve as guidance rather than strict requirements, with no minimum submission threshold, and do not lead to certification denial if risks are identified. They also apply to hydrogen delivery (conditioning, transport, storage) and, in certain cases, to R&D projects.

Hydrogen-Specific vs. Generic

The CBI certification scheme adopts a combined approach, integrating generic components from the overarching Climate Bonds Standard with hydrogen-specific elements defined in the Hydrogen Eligibility Criteria.

Binding vs. Voluntary

The standard and certification scheme are voluntary.

Scope

This framework enables the certification of both Use-of-Proceeds bonds (financing hydrogen production facilities, decarbonization of existing facilities, and hydrogen delivery, such as conditioning and transportation) and Sustainability Linked Bonds (SLBs), as well as the hydrogen production facilities themselves. Eligible entities within this scope include hydrogen producers, equipment manufacturers (such as electrolyzer manufacturers), gas network operators, transportation companies, and storage facility operators.

CBI aims to be a global certifier, independent of regional regulations like the EU's Renewable Energy Directive. The current hydrogen criteria framework was launched in November 2022 (revised in November 2023), and, as of March 2026, no producers have been certified.

CertHiLAC

Announced at COP28 in 2023, CertHiLAC is a collaborative initiative led by the Inter-American Development Bank and the Latin American and Caribbean Energy Organization (OLADE) to establish a regional certification scheme for clean hydrogen in Latin America and the Caribbean (LAC). The initiative has been endorsed by 14 member countries, including Argentina, Bolivia, Chile, Colombia, and Mexico (Hartmann et al., 2023).

The scheme aims to ensure full product traceability by providing detailed information on carbon intensity and production technologies, while also incorporating environmental and social sustainability attributes that reflect regional conditions. Development of the certification system is ongoing; The system is designed to provide an interoperable system that enables alignment with a variety of international requirements without constituting a uniform international legal concept. Nonetheless, two certification categories are planned: one tailored to the LAC region (interoperable with international requirements) and one specifically aligned with EU requirements for exports.

Sustainability Dimensions Covered

The LAC-focused scheme integrates broader sustainability aspects, including minimizing environmental impacts, compliance with international labor standards, wastewater management (e.g., treatment of brine), sustainable water sourcing and land use, avoidance of land-use conflicts, and positive impacts on local—particularly Indigenous—communities. No specific production pathway or explicit greenhouse gas (GHG) emission threshold is required for this scheme. This allows the interoperability with a variety of export markets. For this purpose, CertHiLAC is expected to release additional guidelines addressing specific sustainability aspects, which will serve as the foundation for the program.

The EU-oriented scheme requires compliance with the European Commission's RFNBO definition, while also partially extending the scope to cover water sustainability and the protection of indigenous peoples' rights. These two dimensions are particularly relevant given that many potential hydrogen projects in the region may be located in arid zones with high water demand, and that projects are likely to affect indigenous territories. Neither aspect is currently included in EU hydrogen-specific regulation, highlighting CertHiLAC's potential to add regionally relevant safeguards (Hartmann et al., 2023).

Binding vs. Voluntary

CertHiLac aims to provide a voluntary certification system. As CertHiLAC cannot override national legislation in participating countries, its role is primarily to encourage and sensitize developers rather than impose strict obligations. Companies are expected to demonstrate commitments through their own policies, while certification bodies may issue recommendations. For instance, projects in arid areas may be encouraged to avoid groundwater extraction and instead use treated wastewater. Overall, it is designed to complement and operationalize national regulatory frameworks, enabling future regulatory uptake without modifying its voluntary nature.

Scope

The certification scheme addresses hydrogen production projects in Latin America and the Caribbean, targeting the 14 countries that have endorsed the framework (Hartmann et al., 2023). CertHiLac is designed to enable alignment with international requirements while taking into account the specific characteristics of the region. While generally designed for broader international interoperability, the second certification category addresses EU requirements for RFNBO-compliant hydrogen. Exact specifications are still being developed.

Generally, the scheme foresees accredited certification bodies that can simultaneously verify compliance with international requirements and CertHiLAC's additional sustainability criteria (e.g., through TÜV Süd, Bureau Veritas). Member-state authorities will maintain lists of such accredited entities. A pre-certification process is also planned, supported by a centralized database containing detailed project characteristics (e.g., ownership, transaction history, and sustainability attributes). The scheme is still under development.

TÜV SÜD Standard CMS 70

TÜV SÜD is an independent technical inspection and certification organization headquartered in Germany and operating internationally. It provides certification services across various industrial sectors, including automotive, energy, and construction. The organization introduced its Green Hydrogen Certification Standard CMS 70 in 2011. The most recent version is closely (but not entirely) aligned with the requirements of the EU RED II, emphasizing the transition of energy production to renewable sources and Renewable Fuels of Non-Biological Origin (RFNBOs) (TÜV SÜD, n.d.).

The CMS 70 certification distinguishes between basic requirements, the fulfilment of which entitles producers to use the designation TÜV SÜD GreenHydrogen / GreenHydrogen Derivatives, and additional, more stringent requirements that qualify producers for the TÜV SÜD GreenHydrogen+ / GreenHydrogen Derivatives+ label (TÜV SÜD, 2024).

Sustainability Dimensions Covered (1) – Climate and Renewability Aspects

The standard defines the following climate-related requirements for hydrogen and hydrogen derivatives (ibid.):

- **GHG Emission Reduction:** Certified hydrogen and derivatives must achieve at least a 70% reduction in greenhouse gas emissions compared to the RED II reference values for fossil fuels or biofuels. This corresponds to a threshold of 3.38 kg CO₂e per kg H₂ for hydrogen used in energy storage, mobility, or for industry use cases, and 2.88 kg CO₂e per kg H₂ when hydrogen is used for steam or heat production for heating or cooling purposes.
- **System Boundaries:** Certification applies to Well-to-Gate; for the '+' certification, Well-to-Consumption Gate (or the specific point of delivery, e.g., filling station) is required.
- **Energy Sources and Input Materials:** Hydrogen production shall exclusively use renewable energy, with biomass permitted as a primary energy source if certified under an EC RED II-recognized scheme. Electricity and gaseous energy carriers must be verifiably renewable, and nitrogen for ammonia synthesis, as well as desalinated water, must likewise be produced entirely using renewable energy.
- **Additionality, Temporal and Geographic Correlation (for '+' certification only):** Electrolysis must commence operation within 36 months after the corresponding renewable energy source becomes operational. Hourly matching of electricity supply and consumption is required, and the electrolysis capacity must be located within the same bidding zone as the electricity source.
- **GHG Accounting:** The GHG balance or product carbon footprint must comply with ISO 14040/14044, ISO 14067, the RED II DA methodology, or the GHG Protocol.
- **GHG Threshold for Existing Installations:** For facilities operating before the initial certification, hydrogen and derivative products must remain below a threshold of 91 g

CO₂e/MJ (~3.28 kg CO₂e/kg H₂) over a 12-month period (up to two years retroactively).

- **CO₂ Sources:** When CO₂ is used for derivative production, only CO₂ from priced industrial processes, direct air capture, sustainable biomass combustion, certified RFNBO combustion, or natural geological sources is permitted. CO₂ intentionally generated for capture or already credited under other policy mechanisms is excluded. All sources must be verified through independent third-party evidence or audits.

Sustainability Dimensions Covered (2) –Broader Sustainability Aspects

The standard specifies, to a certain extent, broader sustainability-related requirements for hydrogen and its derivatives. As such, water sources from regions experiencing high or extremely high water stress are not eligible for certified production. For all water sources used, their origin must be specified and verified. Additionally, in regions with medium to high water stress, a comprehensive water supply concept and a water efficiency management system are required (TÜV SÜD, 2024). These criteria are minimum requirements. Where national regulations impose stricter obligations, these must also be fulfilled.

Hydrogen-Specific vs. Generic

The CMS 70 certification is explicitly designed for hydrogen and hydrogen derivatives.

Binding vs. Voluntary

Certification under CMS 70 is voluntary and can be applied globally.

Scope

TÜV SÜD CMS 70 covers the production of hydrogen and derivatives generated using renewable energy. Derivatives include products like synthetic methane, methanol, ammonia, urea, and kerosene (TÜV SÜD, 2024). The CMS 70 certification is not recognized by the European Commission as a voluntary scheme for demonstrating compliance with EU RED II, but shares similar characteristics to other recognized schemes.

Synthesis of Sustainability-Related Standards and Certification Schemes

Table 12 provides a summary of standards and certification schemes that address broader sustainability dimensions for hydrogen.

With regard to sustainability standards, only a draft developed by the German DIN committee was identified (DIN 35809:2025-09). It covers 19 sustainability aspects categorized into environmental, social, governance, and economic dimensions.

Among certification schemes, the Green Hydrogen Standard and the RSB Global Fuels Certification stand out, covering all four sustainability dimensions comprehensively. Other frameworks, such as the Climate Bonds Standards and Certification Scheme and CertHiLac, offer a degree of flexibility. The CertHiLac framework, reflecting the interests of 14 endorsing states, provides guidance rather than prescriptive requirements for broader sustainability aspects, ensuring environmental and social concerns are safeguarded. The evolving CertHiLac initiative is particularly noteworthy as it seeks to integrate requirements from targeted hydrogen import markets (EU) while accounting for the interests of exporting countries. It is still under development. Similarly, the CBI certification scheme enforces mandatory GHG emission thresholds but presents broader sustainability criteria primarily as guidance or recommendations.

All certification schemes referenced focus on renewable hydrogen production; however, approaches to climate-related aspects and GHG reduction targets vary. For instance, the Green Hydrogen Standard targets 1 kg CO₂e/kg H₂, RSB Global Fuels aligns with EU RED II thresholds at 3.38 kg CO₂e/kg H₂, and the CBI scheme aims to align with near net-zero goals by 2050. TÜV SÜD differentiates thresholds according to specific use cases. All these certification schemes are voluntary and globally applicable. They generally categorize requirements as mandatory, expected/recommended, or optional, reflecting varying degrees of compliance. These frameworks address not only hydrogen production but also a range of hydrogen derivatives. Notably, the CBI Hydrogen Eligibility Criteria additionally allow certification of bonds intended to finance hydrogen-related investments and hydrogen production projects themselves.

Overall, there is a limited number of hydrogen projects that have received certification from the sustainability-related certification schemes under study.

TABLE 12: SUSTAINABILITY-RELATED STANDARDS AND CERTIFICATION SCHEMES IN THE HYDROGEN SECTOR

Sustainability Dimensions Covered									
Name	Type	Climate	Renewability	Environment	Social	Specific vs. Generic	System Boundaries and Emission Threshold	Binding vs. Voluntary	Scope
DIN 35809:2025-09 (Draft)	Standard	(X)		X	X	Specific	Threshold applicable as in the relevant market. System boundaries may vary depending on the chosen methodology.	Voluntary. Principles, criteria, and indicators are mandatory to be followed	Hydrogen and hydrogen derivatives
Green Hydrogen Organisation (GH2)	Certification	X	X	X	X	Specific	Well-to-wheel approach; 1 kg CO ₂ e/kg H ₂ .	Voluntary Scheme; Mandatory, Expected, and Optional Elements	Hydrogen and hydrogen derivatives
RSB Global Fuels	Certification	X	X	X	X	Generic, but consists of specific categories relevant to hydrogen	Well-to-wheel approach; 3.4 kg CO ₂ e/kg H ₂ . Allows “free allocation” of renewable and non-renewable electricity share on the product.	Voluntary Scheme; Primarily mandatory criteria, complemented by recommended, permissible, and optional requirements.	Hydrogen and hydrogen derivatives
Climate Bonds Standard (Hydrogen Eligibility Criteria)	Certification	X		(X)	(X)	Generic, but offers sector-specific criteria, with a dedicated framework for hydrogen	Well-to-Consumption Gate Threshold: Gradual reduction from 3.0 kg CO ₂ e/kg H ₂ to “close-to-zero” by 2050 through two intermediate steps	Voluntary Scheme; Only climate-related criteria are mandatory; social & environmental aspects included guidance without binding requirements	Financial instruments supporting investment in hydrogen projects; Hydrogen projects themselves
CertHiLac Initiative*	Certification	X	X	(X)*	(X)*	Specific	The international certification category currently follows the EU RED methodology and threshold (Well-to-wheel; 3.38 kg CO ₂ e/ kg H ₂); LAC-focused scheme yet to be determined	Voluntary Scheme; Broader sustainability claims based on recommendations & best practices	Hydrogen and hydrogen derivatives
TÜV SÜD CMS 70	Certification	X	X	(X)		Specific	Basic Requirements: Well-To-Gate; Optional: Well-to-Consumption Gate; 3.38 kg CO ₂ e per kg H ₂ for usage for mobility, industrial usage, or storage; 2.88 for steam, heating, and cooling purposes	Voluntary Scheme. Only mandatory elements; optional criteria allow an upgraded label.	Hydrogen and hydrogen derivatives; globally applicable

Source: Authors

*Final determination pending, as the certification is still under development.

7.2 GHG Accounting Standards and Certification Schemes

Key Highlights for Hydrogen Sustainability

- GHG accounting standards play an important role in enabling the comparability of hydrogen-related emissions across markets and production pathways, while certification schemes provide the mechanism to demonstrate compliance with jurisdiction-specific requirements.
- Significant international divergence persists regarding applied system boundaries, emission thresholds, required production pathways and primary energy sources, as well as the terminology used to classify hydrogen.
- At the international level, ISO/TS 19870:2023 represents an important step toward a globally referenced methodology for hydrogen GHG accounting.
- A wide range of GHG-focused certification schemes has developed globally. Many are primarily designed to demonstrate compliance with regulatory requirements in specific markets—for example, voluntary certification schemes recognized under the EU Renewable Energy Directive (RED).

In addition to formal standards and certification schemes that address sustainability more broadly - as discussed in the previous subchapter - a range of schemes has emerged that concentrate specifically on greenhouse gas (GHG) emissions and climate-related aspects, or that combine such emissions criteria with requirements for the exclusive use of renewable energy sources. The following section provides a brief overview of the most important schemes and their main characteristics, summarized in Table 13 further below.

Market and Jurisdiction

GHG accounting standards and certification schemes differ with regard to their geographical scope. Some schemes are designed as international schemes, while others are applicable in specific national or regional markets. The ISO technical specification (ISO/TS) 19870:2023 'Methodologies for determining the GHG emissions associated with the production, conditioning, and transport of hydrogen' is the reference point for public and private schemes (see Box 7 for more details). So far, the ISO/TS is the only document on GHG accounting methodology issued by a formal standardization body. The Green Hydrogen Organisation, the RSB Global Fuels Certification Scheme, and Bureau Veritas' Renewable Hydrogen certification all cite the ISO/TS 19870. These certification schemes are generally designed to be applied across jurisdictions and to support international comparability.

Other schemes are explicitly tailored to specific markets and regulatory contexts. Examples include China's Clean and Low-Carbon Hydrogen Evaluation Standard, the United States' Clean Hydrogen Production Standard (CHPS), and certification schemes like CertifHy EU RFNBO, REDcert-EU, and ISCC EU, to show compliance with renewable and RFNBO-compliant hydrogen in the European Union. Comparable jurisdiction-specific schemes also exist or are under development in the United Kingdom, India, Brazil, and other countries. As mentioned, none of the national standardization bodies has issued a GHG accounting methodology so far, although China's Clean and Low-Carbon Hydrogen Evaluation Standard, issued by China's National Energy Administration, takes on a similar character as a formal standard within the Chinese system.

Box 7: ISO/TS 19870:2023: Methodologies for determining the GHG emissions associated with the production, conditioning, and transport of hydrogen.

The International Organization for Standardization (ISO) has developed ISO/TS 19870:2023, a Technical Specification (TS) that outlines methodologies for calculating greenhouse gas (GHG) emissions associated with the production, conditioning, and transport of hydrogen.

Although not yet a full standard, ISO/TS 19870 provides a comprehensive framework for assessing the carbon footprint of hydrogen technologies. It adopts a well-to-consumption gate approach, covering emissions from input materials—such as natural gas and electricity—as well as from conditioning, conversion, transport, and distribution (ISO, n.d.). By providing a common benchmark, it enables countries to implement consistent policies without specifying regulatory thresholds.

Importantly, ISO/TS 19870 does not define acceptable emission levels for any jurisdiction or policy context. Instead, it serves as a foundational tool to establish a shared understanding and common language across stakeholders. The specification is designed to increase transparency for investors and end-users, support bankable offtake agreements, and enable fair competition among hydrogen pathways based on their GHG emissions (Tchouvelev, 2024).

The TS originated from a multi-stakeholder initiative led by the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), whose 2021 GHG assessment methodology was the starting point for the development of ISO/TS 19870 (IRENA, 2024b, p. 33).

The TS shall gradually be replaced by four documents representing steps toward a full ISO International Standard in the future, all addressing methodologies for determining GHG emissions across the hydrogen supply chain (ISO, n.d.):

- ISO 19870-1. Part 1: Emissions associated with the production of hydrogen up to the production gate.
- ISO/DIS 19870-2. Part 2: Emissions associated with the conditioning and transport of gaseous and liquid hydrogen up to the consumption gate
- ISO/DIS 19870-3. Part III: Emissions associated with the production, storage and transport of ammonia up to delivery gate and the conversion of ammonia into hydrogen.
- ISO/DIS 19870-4. Part 3: Emissions associated with the storage and transport of hydrogen via LOHC.

As of the end of March 2026, ISO 19870-1 (Part 1) is in its final production stage and is set for publication in the coming weeks, while the three remaining parts are currently at the 'Draft International Standard' (DIS) stage and are undergoing the enquiry phase with ISO members.

System Boundaries

Across international hydrogen markets, GHG accounting standards and certification schemes apply different system boundary definitions. The narrowest system boundary identified is a gate-to-gate approach, which considers only emissions directly associated with the hydrogen production process itself. This approach has been used in early definitions of “clean hydrogen” in the United States (See Chapters 4.1 and 4.2). However, this has since been refined through the introduction of the Clean Hydrogen Production Standard (CHPS), which applies a well-to-gate methodology. A well-to-gate system boundary includes emissions from upstream processes (e.g., electricity generation for electrolysis or feedstock extraction) as well as emissions occurring during hydrogen production. Schemes applying this approach include the Green Hydrogen Certification India (GHCI), the Clean Hydrogen Certification Scheme in South Korea, China’s Clean and Low-Carbon Hydrogen Evaluation Standard (DL/T 3015-2025), the U.S. CHPS, and private-led initiatives such as the Green Hydrogen Standard.

More comprehensive approaches apply a well-to-wheel (alternatively: well-to-use) system boundary, which also accounts for emissions during the use phase of hydrogen. This approach is applied by the European Union through the Renewable Energy Directive (RED) and its recognized voluntary certification schemes, such as ISCC EU and CertifHy EU RFNBO. Similar system boundaries are also used by international voluntary schemes such as the RSB Global Fuels Certification Scheme. Some schemes allow flexibility in the choice of system boundaries. For example, TÜV SÜD CMS 70 allows certification based on either a well-to-gate or a well-to-consumption-gate approach.

GHG Emission Thresholds

System boundary definitions are closely linked to the application of GHG emission thresholds, as comparability depends not only on numerical thresholds but also on the scope of emissions considered.

The most stringent international scheme with a well-to-gate system boundary is the Green Hydrogen Standard, with a threshold of 1 kg CO₂-e/kg H₂. Korea has a tiered certification scheme, which includes a top tier with a maximum of 0.1 kg CO₂-e/kg H₂, and three additional tiers of 0.11 – 1, 1.01 – 2, 2.01 – 4 kg CO₂-e/kg H₂. The Green Hydrogen Certification India (GHCI), China's Clean and Low-Carbon Hydrogen Evaluation Standard for renewable hydrogen, as well as the Bureau Veritas Renewable Hydrogen certification scheme, all apply a threshold of 2 kg CO₂-e/kg H₂, while the UK's Low-Carbon Hydrogen Certification Scheme applies 2.4 kg CO₂-e/kg H₂. The Japan Hydrogen Society Promotion Act sets a threshold of 3.4 kg CO₂-e/kg H₂. A number of thresholds also apply thresholds of around 4 kg CO₂-e/kg H₂, including the upper tier of Korea's scheme, China's Clean and Low-Carbon Hydrogen Evaluation Standard for clean hydrogen, the U.S. CHPS, and the NGC scheme offered by CertifHy. The least ambitious is China's Clean and Low-Carbon Hydrogen Evaluation Standard for low-carbon hydrogen, which defines a threshold of 13.23 kg CO₂-e/kg H₂.

The Climate Bonds Standard and Certification Scheme (Hydrogen Eligibility Criteria) applies a well-to-consumption gate system boundary with a threshold currently set at 3 kg CO₂-e/kg H₂. This is planned to decline over time and reach near-zero emissions by 2050. TÜV Süd CMS70 scheme sets a threshold of 2.88 kg CO₂-e/kg H₂ for hydrogen used in heat, steam and cooling applications and 3.38 kg CO₂-e/kg H₂ for other applications.

Finally, the EU RED and related certification schemes, along with the RSB Global Fuels Certification, apply a well-to-wheel system boundary with a threshold of 3.38 kg CO₂-eq/kg H₂. The Brazilian System of Hydrogen Certification (SBCH2) has set a threshold of 7 kg CO₂-e/kg H₂, but has yet to formally define the applicable system boundary.

Required Production Pathway

In addition to differences in system boundaries and emission thresholds, certification schemes vary with regard to eligible hydrogen production pathways. Some schemes exclusively allow electrolysis-based hydrogen produced using renewable energy sources. This applies, for example, to the RFNBO category under the EU Renewable Energy Directive and its recognized voluntary certification schemes, as well as private initiatives such as the Green Hydrogen Standard and the RSB Global Fuels Certification Scheme. China's Clean and Low-Carbon Hydrogen Evaluation Standard also applies this restriction for its renewable hydrogen category.

Other schemes permit additional production pathways, including hydrogen derived from biomass. Examples include the Brazilian System of Hydrogen Certification (SBCH2), TÜV SÜD CMS 70 or the Green Hydrogen Certification India (GHCI).

A large number of schemes do not prescribe specific production pathways. Instead, compliance is determined primarily by meeting the defined carbon intensity threshold, theoretically allowing any production route. This approach is used by the Clean Hydrogen Certification Scheme in Korea, the Japan Hydrogen Society Promotion Act, China's Evaluation Standard (for low-carbon and clean hydrogen), the U.S. CHPS, and private initiatives such as the Climate Bonds Standard and Certification Scheme.

Terminology

Finally, schemes differ in the terminology used to classify hydrogen, reflecting differences in regulatory focus and policy objectives.

- Low-carbon hydrogen: Brazil; UK Low-Carbon Hydrogen Certification Scheme; Climate Bonds Standard and Certification Scheme; Japan Hydrogen Society Promotion Act; China's Low-Carbon Hydrogen Evaluation Standard
- Clean hydrogen: China's Clean Hydrogen Evaluation Standard; U.S. CHPS; South Korea's Clean Hydrogen Certification Scheme
- Green hydrogen: Green Hydrogen Certification India (GHCI); GH₂ Organisation; CertifHy (CertifHy NGC); TÜV SÜD CMS 70
- Renewable hydrogen: RSB Global Fuels Certification Scheme; EU Renewable Energy Directive and recognized voluntary schemes; China's Clean and Low-Carbon Hydrogen Evaluation Standard (for renewable hydrogen)

TABLE 13: GHG ACCOUNTING CERTIFICATION SCHEMES AND STANDARDS

Scheme Name	Type	Market/Jurisdiction	System Boundary	Emission Threshold [kgCO ₂ e/kgH ₂]	Required Production Pathway	Terminology	Remark	Source
Standards								
ISO/TS 19870:2023	Standard	International	Well-To-Gate	n/a	Any	n/a	Defines methodology for GHG Emission calculation for the production, conversion, and transport of hydrogen.	(ISO, n.d.).
Clean and Low-Carbon Hydrogen Evaluation Standard for Renewable Hydrogen	Standard	China	Well-to-Gate	2	Electrolysis using renewable energy sources	Renewable Hydrogen		Tao (2025); H2CN (2026)
Clean & Low-Carbon Hydrogen Evaluation Standard for Clean Hydrogen	Standard	China	Well-to-Gate	3.86	Any	Clean Hydrogen		Tao (2025); H2CN (2026)
Clean & Low-Carbon Hydrogen Evaluation Standard for Low-Carbon Hydrogen	Standard	China	Well-to-Gate	13.23	Any	Low-Carbon Hydrogen		Tao (2025); H2CN (2026)
Certification Schemes								
Green Hydrogen Standard and Certification Scheme	Certification	Global application, voluntary	Well-To-Gate	1	Electrolysis using renewable energy sources	Green Hydrogen		GH ₂ (2023b)
Green Hydrogen Certification India (GHCI)	Certification	India	Well-To-Gate	2	Electrolysis using renewable energy sources, biomass	Green Hydrogen		Ito et al. (2025)
Bureau Veritas Renewable Hydrogen	Certification	Global application, voluntary	Well-To-Gate	2	Electrolysis using renewable energy sources	Renewable Hydrogen		Bureau Veritas (2023)
UK Low Carbon H₂ Certification Scheme	Certification	UK	Well-To-Gate	2.4	Electrolysis, Nat. Gas + CCUS, biomass & waste	Low-Carbon Hydrogen	Scheme under Development (originally planned to become operational in 2025)	DESNZ (2023, 2024)
Clean Hydrogen Certification Scheme	Certification	South Korea	Well-To-Gate	Four Levels: 0 - 0.1 0.11 - 1 1.01 - 2 2.01 - 4	Any	Clean Hydrogen		Ito et al. (2025)

Scheme Name	Type	Market/ Jurisdiction	System Boundary	Emission Threshold [kgCO ₂ e/kgH ₂]	Required Production Pathway	Terminology	Remark	Source
Climate Bonds Standard and Certification Scheme (H₂ Eligibility Criteria)	Certification	Global application, voluntary	Well-To-Consumption-Gate	2022: 3.0; 2030: 1.5 2040: 0.6; 2050: "close to zero"	Any	Low-Carbon Hydrogen		CBI (2023)
TÜV SÜD CMS 70	Certification	Global application, voluntary	Well-to-Gate/ Well-to-Consumption-Gate	2.88 - 3.38	Electrolysis using renewable energy sources, biomass, biomethane, biogenic residues	Green Hydrogen	Lower emission threshold applies to H ₂ used in heat, steam, and cooling, higher threshold applies to other applications. System boundary may extend to point-of-delivery, though well-to-gate is acceptable	TÜV SÜD (2024)
ISCC EU	Certification	Hydrogen for the regulated EU market	Well-To-Wheel	3.38	Electrolysis using renewable energy sources	Renewable Hydrogen		IEA (2024)
CertifHy EU RFNBO	Certification	Hydrogen for the regulated EU market	Well-To-Wheel	3.38	Electrolysis using renewable energy sources	Renewable Hydrogen		CertifHy, (2025)
REDcert-EU	Certification	Hydrogen for the regulated EU market	Well-To-Wheel	3.38	Electrolysis using renewable energy sources	RFNBO-Hydrogen, Green Hydrogen		REDcert GmbH (2024)
RSB Global Fuels Certification	Certification	Global application, voluntary	Well-To-Wheel	3.38	Electrolysis using renewable energy sources	Renewable Hydrogen		RSB (2023a)
CertifHy Non-Governmental Certification (NGC)	Certification	EEA + Switzerland	Well-to-Gate	4.37	Renewable Energy Source for Green Hydrogen; any pathway for Low-Carbon Hydrogen	Green Hydrogen; Low-Carbon Hydrogen	60% emissions savings compared to fossil comparator (set at 91 gCO ₂ e/MJ LHV)	CertifHy (2022, p.8), (CertifHy, 2022a) CertifHy (n.d.)
Brazilian System of Hydrogen Certification (SBCH2)	Certification	Brazil	Yet to be defined	7	Low-Carbon H ₂ : any pathway. Renewable H ₂ : Hydrogen produced from renewable sources, including natural hydrogen, biofuels, or electrolysis powered by renewable energy. Green H ₂ : Water Electrolysis using renewable energy sources.	Low-Carbon, Renewable, Green Hydrogen		Mattos Filho (2024a)

Scheme Name	Type	Market/ Jurisdiction	System Boundary	Emission Threshold [kgCO ₂ e/ kgH ₂]	Required Production Pathway	Terminology	Remark	Source
<i>Emission Thresholds as Defined in Regulation</i>								
EU RED and Delegated Acts	Threshold	EU	Well-To-Wheel	3.38	Electrolysis using renewable energy sources	Renewable Hydrogen / RFNBO-compliant Hydrogen	Define how hydrogen must be produced to count toward the EU's renewable hydrogen production and import targets. Additional rules applicable, including a 70% compared reduction compared to a fossil comparator	(H4D Partnership, 2024).
EU Hydrogen & Gas Decarbonisation Package	Threshold	EU	Well-To-Wheel	3.38	SMR with CCS/CCU, electrolysis using grid electricity	Low-Carbon Hydrogen	Sets rules for low-carbon hydrogen from non-renewable sources	Directive (EU) 2024/1788; CDR (EU) 2025/2359
Japan Hydrogen Society Promotion Act	Threshold	Japan	Well-To-Gate	3.4	Any	Low-Carbon Hydrogen	Meeting the threshold is required to qualify for government funding (contract-for-difference)	Ito et al. (2025)
Clean Hydrogen Production Standard (CHPS)	Threshold	USA	Well-To-Gate	4	Any	Clean Hydrogen		Eicke (2025)

Source: Authors

8 Sustainability Governance of Hydrogen in Public and Private Finance

This chapter examines sustainability governance mechanisms in the hydrogen sector, focusing on instruments developed or adopted by actors in both public and private finance. It begins by presenting the environmental and social safeguard policies of multilateral development banks (Chapter 8.1), which already play a significant role in enabling sustainable hydrogen, as they are applied in the financing of hydrogen projects already today.

Subsequently, the chapter introduces selected ESG frameworks for managing environmental and social risks, as well as for disclosure and reporting, that are internationally recognized and widely used by a range of stakeholders, including those already active in the hydrogen sector (Chapter 8.2). Chapter 8.3 focuses on the analysis of private ESG frameworks.

8.1 E&S Safeguard Policies of Multilateral Development Banks for Hydrogen Sustainability

Key Highlights for Hydrogen Sustainability

- Multilateral Development Banks (MDBs) play a critical role in developing the hydrogen economy, providing financing and technical assistance across the hydrogen value chain already today.
- MDBs generally implement risk-based Environmental and Social (E&S) Policy frameworks covering multiple sustainability dimensions, typically including due diligence processes.
- Early developments for hydrogen-specific guidelines have evolved, through the technical note 'Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean', developed by the Inter-American Development Bank.
- MDB frameworks, in particular the IFC Performance Standards, serve as benchmarks and reference points for other governance instruments and initiatives, including the certification schemes by RSB and the Green Hydrogen Organisation, the H2Global mechanism, KfW Development Bank, the Equator Principles, and, in parts, the EU Taxonomy DNSH criteria.

Multilateral Development Banks (MDBs) play a central role in supporting and shaping global hydrogen value chains. They facilitate project financing, particularly for emerging technologies like green hydrogen, by mitigating risk where private investment is limited. A common form of MDB support is the provision of loans to project beneficiaries, typically accompanied by a set of stringent environmental and social requirements.

To manage these obligations systematically, MDBs have consolidated their environmental and social requirements into comprehensive Environmental and Social (E&S) Safeguard Policies (or similarly titled systems). These frameworks are grounded in a risk-based approach to sustainability (Blanc & Franco-Temple, 2013), emphasizing the assessment, minimization, and responsible management of potential adverse impacts. When projects apply for MDB financing, the principle of risk proportionality is applied through early-stage impact and risk categorization. This determines the degree of due diligence and monitoring required for each project. Common classification systems include the following categories:

- **Category A / High Risk:** Activities with potentially significant adverse environmental or social impacts that are diverse, irreversible, or unprecedented.
- **Category B / Medium Risk:** Activities with limited adverse impacts that are generally site-specific, largely reversible, and mitigable through targeted measures.
- **Category C / Low Risk:** Activities with minimal or negligible adverse environmental or social impacts.

Sustainability Dimensions Covered

Typically, MDBs address broadly the same sustainability-related themes, including labor and working conditions, biodiversity conservation, protection of vulnerable groups (including Indigenous Peoples), land and livelihood issues, pollution prevention and resource efficiency, health and safety standards, and the preservation of cultural heritage. Similarly, the risk-based procedural approach is consistent across institutions. MDBs usually rely on a common procedural framework, encompassing impact assessments, grievance mechanisms, and other risk management processes, reflecting a shared underlying logic for sustainability governance (see, for example, Kvam, 2019). Additionally, MDBs define substantive requirements, for example, relating to specific criteria or aspects that disqualify their support. For instance, MDBs typically require that projects not rely on child labor.

Overall, the thematic scope as well as the procedural architecture of these frameworks are largely harmonized. However, the concrete policy stringency of specific requirements — such as the thresholds for impact assessments, the scope and content of biodiversity and ecosystem service management obligations, the prescriptiveness of labor and occupational health standards, or the conditions under which resettlement and compensation measures are triggered — differs. As these divergences are crucial for understanding the practical implications of MDB sustainability policies, they will be further investigated in a forthcoming RIFS study on the role of multilateral development banks in hydrogen sustainability.

For an illustrative example of how MDBs address these aspects, see Box 8 (below) of the IFC Performance Standards, which form a core component of the IFC's sustainability framework and are increasingly referenced in other sustainability governance mechanisms.

Hydrogen-Specific vs. Generic

The MDB's E&S frameworks are applicable across various sectors and are generic in nature, but several of their provisions, in particular, specific risks, are directly relevant to hydrogen projects. For example, large-scale green hydrogen production may require extensive land areas for electricity generation from renewable energy sources, creating potential social risks related to land acquisition and resettlement. Such issues are typically explicitly addressed within the existing E&S frameworks. Banks such as the IFC develop Environmental, Health, and Safety (EHS) Guidelines for specific sectors, including oil, gas, mining, and power (See IFC, 2024).

The development of sector-specific guidelines for hydrogen projects has only recently gained more prominence, visible, for example, through a technical note and scoping study, developed by the Inter-American Development Bank (IDB), titled: 'Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean' (Signoria & Barlettani, 2025). Therein, the authors provide a comprehensive analysis of environmental, health, safety, and social risks across the entire green hydrogen value chain, from production and water supply to transportation and conversion into derivatives such as ammonia or methanol. A key contribution of the study is the systematic mapping of these risks against the bank's ten Environmental and Social Performance Standards, which are generally aligned with the IFC Performance Standards. In doing so, the study identifies specific gaps and provides 'preliminary considerations for a sectoral guideline'. It addresses hydrogen-specific complexities such as the criteria for water and energy 'additionality', the environmental management of brine discharge from desalination processes, and safety protocols required for hydrogen infrastructure. Another illustrative example of IDB's engagement for hydrogen sector development is the CertHiLac initiative to develop a hydrogen certification scheme for Latin America and the Caribbean (see Chapter 7.1).

Box 8: IFC Performance Standards: Overview and International Benchmark

The IFC Performance Standards on Environmental and Social Sustainability (IFC Performance Standards) (IFC, 2012) constitute the primary benchmark against which the environmental and social (E&S) performance of IFC-financed projects is evaluated. They define the core compliance obligations for IFC borrowers and are legally binding within IFC's contractual agreements. Additionally, the standards provide comprehensive guidance on the identification, assessment, and management of E&S risks and impacts associated with IFC-supported activities. The Performance standards are:

1. Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
2. Performance Standard 2: Labor and Working Conditions
3. Performance Standard 3: Resource Efficiency and Pollution Prevention
4. Performance Standard 4: Community Health, Safety, and Security
5. Performance Standard 5: Land Acquisition and Involuntary Resettlement
6. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
7. Performance Standard 7: Indigenous Peoples
8. Performance Standard 8: Cultural Heritage

Performance Standard 1 is foundational, establishing the importance of an integrated assessment to identify E&S impacts, risks, and opportunities. It underscores the need to manage E&S performance throughout the project lifecycle via an effective Environmental and Social Management System (ESMS). As an umbrella standard, it applies to all IFC investment projects and defines approaches for managing specific risks addressed in the subsequent standards. Performance Standards 2–8 set objectives and requirements to avoid, minimize, mitigate, and compensate for risks and impacts affecting workers, communities, and the environment.

The Performance Standards emphasize that businesses must respect human rights, avoid causing or contributing to adverse impacts, and address them when they occur. Project proponents are required to identify and evaluate potential E&S risks and adopt a mitigation hierarchy to anticipate, avoid, minimize, and, where necessary, compensate or offset adverse effects. The standards are also accompanied by a guidance note for each standard, which provides advice on how to interpret and implement the principles in the standards. In addition, IFC has developed Environmental, Health, and Safety (EHS) Guidelines for various sectors to support effective application, although specific guidance for hydrogen projects is not yet available (IFC, 2024).

Beyond IFC operations, the standards have become an influential benchmark for private sector investment, including within the hydrogen sector. For example, the Equator Principles - a voluntary framework adopted by 128 private financial institutions - are based on the IFC Performance Standards and were developed in close collaboration with IFC staff (Equator Principles, 2024). Within the hydrogen sector, the Green Hydrogen Standard is based on the IFC Performance Standards (GH₂, 2023b). The Climate Bonds Standard (CBI) incorporates the IFC Performance Standards to minimize impacts on land and the assets of vulnerable groups (CBI, 2023). In addition, the Roundtable on Sustainable Biomaterials (RSB) refers to these Standards in its RSB Impact Assessment Guidelines (see Chapter 7.1 for detailed descriptions). The environmental assessments required under the H2Global mechanisms (second auction round) should be aligned with either IFC Performance Standard 1 or the World Bank Environmental and Social Standard 1, while social assessments should be conducted in accordance with the IFC Performance Standards. Bilateral development banks also follow IFC approaches, as reflected in the practices of institutions such as the German development bank KfW.

Overall, the IFC Performance Standards have guided E&S risk management globally for over a decade, and, according to IFC, have influenced more than USD 4.5 trillion in financial flows across emerging markets (IFC, n.d.).

Binding vs. Voluntary

The E&S Safeguard Policies (for the case of IFC, primarily, the Performance Standards), are binding non-negotiable instruments. If the support takes the form of a loan, a loan agreement legally anchors the sustainability obligations of the borrower. During project implementation, MDBs monitor compliance, often linking disbursements to the achievement of specific milestones. Monitoring continues until project completion or full loan repayment (See, for example, IDB, 2020).

Scope

MDBs support hydrogen-related initiatives at various stages of development, across different segments of the value chain. (Engen & Prizzon, 2018). Generally, E&S frameworks apply across the entire project value chain. For instance, IFC Performance Standard 1 specifies that its scope encompasses the project itself (e.g., the project site, transport corridors, and associated watersheds) as well as the client's activities and facilities that are directly owned, operated, or managed by the client, including those implemented through contractors, where these form part of the project. Additionally, the scope also includes associated facilities that are not financed as part of the project but would not have been built or expanded without it. In addition, cumulative impacts should be considered, meaning the combined effects of the project together with other existing, planned, or reasonably foreseeable developments affecting the same areas or resources (IFC, 2012). The specific scope of the due diligence to be conducted also depends on the risk classification of the project, as projects ranked with lower risks, require a less comprehensive assessment.

8.2 ESG Frameworks in Private Finance

Key Highlights for Hydrogen Sustainability

- ESG frameworks support hydrogen sustainability by either guiding the management of ESG-related risks or requiring the disclosure of ESG-relevant information. These approaches target different actors—for example, financial institutions aligning investment decisions with ESG criteria, and companies enhancing transparency for stakeholders through improved reporting.
- Most ESG frameworks are generic and may offer sector-specific guidance, but none currently provide dedicated guidelines for the hydrogen sector.
- The Equator Principles are the most widely used framework for managing ESG risks in project finance, adopted by 128 financial institutions globally. Although voluntary, they are applied by banks that are involved in hydrogen-related activities, like BNP Paribas, ING, and KfW IPEX Bank.
- Several voluntary and partly harmonized standards are used across projects and financial actors to improve reporting consistency and transparency. Key disclosure standards include TNFD, GRI, and the ISSB Standards.

As outlined in Chapter 2.3.2, there are two main types of ESG and sustainability frameworks within the private financial sector: those that focus on managing ESG-related risks and those that focus on disclosing and reporting on them. The following section presents the Equator Principles, the most prominent framework for managing ESG-related risks as well as the three leading frameworks for ESG-related reporting and disclosure. The Equator Principles are widely applied in the financing of large infrastructure projects and can be understood as a private-sector counterpart to the environmental and social policy frameworks used by multilateral development banks. The TNFD provides a methodological approach for identifying, assessing, and disclosing nature-related risks and dependencies, and is increasingly used both directly by organizations and as a reference for other initiatives. The GRI Standards are among the most widely used sustainability reporting frameworks globally. The ISSB Standards aim to establish globally consistent sustainability disclosure standards and are increasingly being adopted by jurisdictions or used as a basis for the development of national reporting systems. The three disclosure frameworks all align with the EU sustainability disclosure regime (see Chapter 8.3).

ESG Frameworks for Managing Social & Environmental Risks

The Equator Principles represent the leading framework that addresses the management of ESG-related risks by private financial institutions.

Equator Principles

The Equator Principles were launched by the International Finance Corporation (IFC) and a group of commercial banks in 2010, and are now overseen by Equator Principles Limited. It provides a risk management framework for financial institutions to assess and manage environmental and social risks in project financing. Under this framework, projects are classified based on their location in either Designated or Non-Designated Countries. Designated Countries have strong environmental and social governance, allowing reliance on national laws. Projects in Non-Designated Countries must demonstrate compliance directly with the IFC Performance standards. Financial institutions adopting the framework become

Equator Principles Financial Institutions (EPFIs), integrating the ten principles into policies, addressing environmental and social impacts, and reporting annually on implementation. The adopters are exclusively financial institutions, encompassing primarily private entities as well as public ones, such as banks and export credit agencies.

Sustainability Dimensions Covered

The Equator Principles classify, similarly to the IFC approaches, projects by environmental and social risk (Principle 1), determining the scope of assessments required (Principle 2). Human rights risks and impacts must also be assessed in accordance with the UN Guiding Principles on Business and Human Rights (UNGPs). Projects must demonstrate stakeholder engagement (Principle 5), establish grievance mechanisms, and undergo rigorous assessment, monitoring, and reporting processes (Principles 6,7,9, and 10). If a project affects Indigenous Communities, it must comply with the concept of Free, Prior, and Informed Consent (Equator Principles, 2024).

In a guidance note from May 2023, it was explicitly emphasized that the Equator Principles should adopt a double materiality perspective to manage climate change risks, considering both the potential impact of these risks on the investment and the broader impact of the investment on the environment and society (Equator Principles, 2023).

Hydrogen-Specific vs. Generic

The Equator Principles are generic in nature, but they apply to hydrogen projects, like any other large infrastructure or industrial project seeking financing from EPFIs.

Binding vs. Voluntary

The Equator Principles are voluntary in nature. As of March 2026, 128 financial institutions have adopted the Equator Principles and become EPFIs (Equator Principles, n.d.). An EPFI is required to apply the Equator Principles to any new project that meets the applicable criteria for the relevant financing type—for example, project finance with a total capital cost exceeding USD 10 million (Equator Principles, 2024; p. 5).

Scope

The focus of the Equator Principles is on enabling risk management when financing projects, and applies globally across all industry sectors and financial products, including project finance, project finance advisory services, project-related corporate loans, bridge loans, and project-related acquisition finance (ibid.).

Among financial institutions involved in hydrogen-related financing under this framework are Santander Bank, BNP Paribas, KfW IPEX-Bank GmbH, Korea Development Bank, and ING Banking Group (Collins, 2023; Equator Principles, n.d.; KfW IPEX Bank, 2023).

ESG Disclosure and Reporting Standards

In addition to mechanisms aimed at actively managing environmental and social risks—such as risk management systems or due diligence processes—there are also widely recognized standards and frameworks for disclosing these risks. These ESG disclosure frameworks are designed to enhance transparency in corporate activities, support more informed investment decisions, and ultimately promote greater sustainability in business practices. The most relevant are described in the following.

Taskforce on Nature-Related Financial Disclosures (TNFD)

The Taskforce on Nature-related Financial Disclosures (TNFD) is a market-led, science-based initiative that helps organizations screen and disclose nature-related risks and opportunities. It brings together senior executives from financial institutions, corporations, and market service providers, whose organizations collectively represent trillions in assets and global market capitalization (Stansfield et al., 2024; TNFD, 2025b). The Taskforce published a set of disclosure recommendations and guidance that encourage businesses and financial institutions to assess, report, and act on their nature-related dependencies, impacts, risks, and opportunities. These efforts support a shift in capital allocation toward “nature-positive” outcomes.

TNFD is increasingly being integrated with and aligned to other sustainability standards, including the GRI Impact Standards, the EU CSRD, and the sustainability reporting standards of the International Sustainability Standards Board (ISSB) (TNFD, 2025b).

Sustainability Dimensions Covered

TNFD reporting is structured around four key pillars (TNFD, 2023a, p. 8):

- **Governance:** Disclosure of human rights policies concerning Indigenous Peoples, local communities, and nature-related risks.
- **Strategy:** Assessment of how nature-related risks and opportunities affect business models, value chains, and financial planning.
- **Risk & Impact Management:** Explanation of methods used to identify, assess, and manage nature-related risks across operations and supply chains.
- **Metrics & Targets:** Reporting on key performance indicators (KPIs) and targets associated with dependencies, impacts, and mitigation of nature-related risks.

These four areas are further subdivided, resulting in 14 specific disclosures that the TNFD recommends for corporate reporting (ibid). Recently, the TNFD adapted its policies to incorporate not only financial materiality, but also to consider the impact of the activities on nature-related risks (TNFD, 2023b, p.19).

Hydrogen-Specific vs. Generic

TNFD does not offer a dedicated framework for hydrogen (yet). TNFD offers sector-specific guidance for industries such as electric utilities, oil & gas, and chemicals. The chemical sector's guidance briefly mentions green hydrogen, highlighting its dependency on water resources (TNFD, 2024).

Binding vs. Voluntary

TNFD reporting is voluntary. As of November 2025, over 730 organizations have committed to nature-related reporting, including asset managers overseeing \$22.4 trillion in assets under management, and publicly listed companies with a total market capitalization of \$9.416 trillion (TNFD, 2025b).

Scope

TNFD reporting has been designed to meet the corporate reporting requirements of organizations across sectors and jurisdictions. Organizations from a wide range of industries have committed to using TNFD reporting or are already implementing it. These actors include over 170 financial institutions as well as companies from diverse sectors—such as oil and gas and renewable energy—spanning upstream, midstream, and downstream operations (TNFD, 2025b).

Among actors involved in hydrogen project development, notable participants include AMEA Power and Iberdrola (see also Box 9), as well as midstream infrastructure operators such as SNAM, and financial institutions including AXA, Commerzbank, and the Japan Bank for International Cooperation (TNFD, 2025a). To illustrate the practical application of TNFD, Iberdrola, a renewable energy and hydrogen production project developer, provides an example (see Box 9; Iberdrola S.A., 2025; WBSCD, 2024).

Box 9: TNFD in practice: Iberdrola Case Study

Iberdrola, a Spanish multinational electric utility and a leader in renewable energy and green hydrogen, demonstrates TNFD application in its reporting and risk management processes. As of March 2026, the company has over 30 green hydrogen projects (including for the production of e-methanol and green ammonia), including a 100 MW solar-powered green hydrogen plant for ammonia production (inaugurated in 2022) near Ciudad Real, Spain (Iberdrola S.A., 2025b).

To implement TNFD, Iberdrola first analyzes its business activities to determine their interactions with nature and ecosystem services. It maps assets located near protected areas such as Ramsar wetlands and Natura 2000 sites, while also monitoring species risks using the IUCN Red List. After identifying key dependencies, including water, mineral, and non-mineral resources, the company evaluates potential impacts, particularly on biodiversity and ecosystem disruption. These impacts are assessed through its Corporate Environmental Footprint (CEF), using standardized Life Cycle Impact Assessment (LCIA) methodologies. Iberdrola incorporates these findings into its Comprehensive Risk Control and Management System, which informs its strategic planning and mitigation efforts. In Spain, for example, biodiversity risk evaluations for power networks and onshore renewables have led to projects such as modifying powerline poles to prevent birds from receiving electric shocks and introducing biodiversity-friendly wind farm designs (WBSCD, 2024).

The company aligns its disclosures with the European Sustainability Reporting Standards (ESRS) and includes this information in its annual Sustainability Report (Iberdrola S.A., 2025a). By following TNFD principles, Iberdrola enhances transparency, manages environmental risks effectively, and aligns with global sustainability standards also having an impact on improvements for the sustainability of hydrogen.

Global Reporting Initiative (GRI)

The Global Reporting Initiative (GRI) is a non-profit organization that provides standards to help organizations assess and disclose their economic, environmental, and social impacts. Founded in 1997 by CERES and the Tellus Institute with UN Environment Programme support, the GRI is a multi-stakeholder-led non-profit. It is governed by boards for management, supervision, and standards, alongside a multi-stakeholder forum and oversight committee, and funded by a mix of institutional, foundation, and private-sector contributions (GRI, 2025c, 2025a, 2025b). The GRI standards enhance transparency and accountability, supporting sustainable development.

Sustainability Dimensions Covered

GRI Standards follow a modular structure consisting of three interconnected series: Universal Standards, Sector Standards, and Topic Standards (GRI, 2023, p. 6):

- **Universal Standards:** Universal Standards underpin GRI reporting, guiding disclosure of material economic, environmental, and social impacts, including human rights, aligned with international frameworks like the UN Guiding Principles on Business and Human Rights and OECD Guidelines.
- **Sector Standards:** Sector Standards assist organizations in determining material topics specific to their industry and defining relevant disclosures. As of the publication of this study, no sector-specific standard for hydrogen exists.
- **Topic Standards:** Topic Standards contain disclosures on specific sustainability issues. Examples include the Rights of Indigenous Peoples Standard, the Supplier Environmental (and Social) Assessment Standard, a Biodiversity standard, and a Climate Change and Energy Standard.

While GRI traditionally focuses on Impact Materiality, GRI reporting helps companies address double materiality by linking these impacts to the financial risks and opportunities they may generate (GRI, 2024). In this context, GRI can also act as an enabler or bridge—for example, by providing training and guidance on how to comply with double materiality requirements as set out in the EU Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS).

Hydrogen-Specific vs. Generic

The GRI Standards provide a generic framework, providing standards for specific sectors (see above). As of March 2026, no sector-specific standard for hydrogen exists.

Binding vs. Voluntary

The GRI standards offer a voluntary framework for sustainability-related disclosures. Despite their voluntary nature, by the end of 2024, GRI standards were referenced in 477 policies worldwide, with 6 jurisdictions mandating their use, and 127 encouraging voluntary adoption. For instance, in Sweden, a 2014 regulation mandates that state-owned companies report their sustainability performance in accordance with GRI guidelines as part of their accountability framework (Chalmers et al., 2024).

Scope

The GRI standards enable any organization to understand and report on the impacts of its business activities on the economy, the environment, and people, in a comparable and credible way. Overall, any organization can use the GRI Standards to produce comprehensive sustainability reports or selectively disclose relevant information for specific stakeholders, such as investors and consumers. In this way, they are relevant to a variety of stakeholders, including investors, policymakers, capital markets, and civil society. In 2022, 78% of the world's 250 largest companies (after revenues) used the GRI Standards, with adoption distributed across the Americas, Asia-Pacific, and Europe, the Middle East, and Africa (GRI, 2022).

Notable actors in the hydrogen sector include Air Products, for instance, through its involvement in the NEOM Green Hydrogen Company in Saudi Arabia, which prepares its corporate sustainability reports in accordance with the GRI Standards (See, for example, its 2024 corporate sustainability report, Air Products, 2024).

International Sustainability Standards Board (ISSB) & Sustainability Disclosure Standards

The International Sustainability Standards Board (ISSB) is an independent body established in November 2021, established by the International Financial Reporting Standards (IFRS) Foundation. The IFRS Foundation has a three-tier governance structure and is a mixed, multi-stakeholder-led initiative. The ISSB is an independent standard-setting board, overseen and appointed by Trustees responsible for strategy, funding, and due process (IFRS, 2025a, 2025c). The Trustees are accountable to the Monitoring Board, composed of government and regulatory authorities, including the European Commission, U.S. Security and Exchange Commission, and China's Ministry of Finance (IFRS, 2023).

ISSB's primary role is to develop and maintain sustainability reporting standards that ensure consistent, comparable, and reliable disclosure of sustainability and climate-related risks across industries and regions. By standardizing sustainability-related financial disclosures, the ISSB aims to address fragmentation in sustainability reporting, primarily for financial market participants (IFRS, 2025b).

Sustainability Dimensions Covered

In June 2023, the ISSB published its inaugural standards: IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and IFRS S2 (Climate-related Disclosures), both based on financial materiality. Collectively, both are referred to as ISSB standards.

IFRS S1 provides a general framework for sustainability reporting, setting out principles for disclosing all material sustainability risks and opportunities. It requires entities to report on governance processes, strategy, risk identification and management, and performance in relation to sustainability-related risks and opportunities. Compliance may be supported through industry-specific standards (the SASB Standards) (IFRS, 2024b). As the standard relates to financial materiality, it also encompasses social and environmental aspects, but only insofar as external factors (environmental, social) affect financial performance, rather than the impact of the economic activities themselves.

IFRS S2 complements this general framework by focusing specifically on climate-related disclosures. It requires reporting on material climate risks and opportunities that could affect cash flows, access to finance, or cost of capital, covering both physical and transition risks. For example, climate-related opportunities may arise when an entity develops new products or services that respond to changing consumer preferences and strengthen its brand reputation – changes themselves driven by climate-related trends. Conversely, a climate-related transition risk may occur if an organization's financial performance is impacted by evolving consumer demand or by the need to adopt new technologies as economies shift toward lower-carbon models (IFRS, 2024b, and Appendix A). Generally,

entities are required to disclose information on governance, strategy, risk management, and performance related to these aspects. Specific quantitative key metrics include greenhouse gas (GHG) emissions—Scope 1 (direct), Scope 2 (indirect), and Scope 3 (value chain), if applicable.

A standard related to environmental aspects, summoned under the term ‘Nature-related Disclosures’ is currently being developed (IFRS, 2026), with a targeted draft to be published for public consultation in the second half of 2026, based on the existing standards from the TNFD (IFRS, 2025e) (see above for more details). A potential standard specifically addressing social aspects, specifically on human capital, is currently being analyzed in a research project conducted by the ISSB.

Hydrogen-Specific vs. Generic

The ISSB Standards provide a generic framework for sustainability reporting. IFRS S1 references the SASB sector standards, which currently cover 77 industries and offer sector-specific guidance and metrics. While no standards currently exist for hydrogen, related standards address sectors such as solar technology, wind power, fuel cells, industrial batteries, and oil and gas (IFRS, 2025d).

Binding vs. Voluntary

The ISSB standards are voluntary in nature. However, many jurisdictions are actively considering ISSB standards for mandatory application or basing the standards in their jurisdiction on them. As of March 2026, ISSB Standards have been adopted, used as a basis for national standards, or are in the process of consultation or finalization in 33 jurisdictions (Deloitte, 2026). For example, Japan released its inaugural Sustainability Reporting Standards, based on IFRS sustainability disclosure standards. This could form the basis of mandatory reporting for listed companies (Segal, 2025). The Corporate Sustainability Disclosure Standards (CSDS) in China are aligned and based on the IFRS Standards. In the EU, the EU CSRD and European Sustainability Reporting Standards (ESRS) are not directly based on the ISSB standard, but have a high degree of alignment (Deloitte, 2026, see also Chapter 8.3).

Scope

The ISSB standards are applicable across industries and jurisdictions and primarily focus on companies reporting on the opportunities, risks, and impacts of their business activities with respect to sustainability aspects. Unlike, for instance, EU regulatory frameworks such as the SFDR and ESRS, the ISSB operates globally. Between October 2023 and March 2024, a total of 1,151 companies globally either referenced the ISSB standards, planned to align their sustainability-related disclosures with these standards, or were already in alignment. Among them, 18 operate in the renewable energy sector, including wind power developers, fuel cell developers, and biofuels, though not hydrogen (IFRS, 2024a).

8.3 Synthesis of Sustainability Governance in Hydrogen Private Finance

Table 14 provides a detailed comparison across the various characteristics outlined in Chapter 2.6. To provide a comprehensive comparison, Table 14 also includes the frameworks from the EU (CSRD and ESRS) and China (CSDS, see respective Chapters 3.3 and 5.3 for details).

The private ESG frameworks analyzed generally address broad sustainability aspects; however, not all explicitly account for the environmental and social impacts of financial or economic activities (impact materiality). Several frameworks focus primarily on sustainability-related risks that affect business or investment outcomes, emphasizing financial materiality rather than impact materiality. All frameworks are designed to be generic, allowing for application across a wide range of economic or financial activities. While there are some sector-specific guidance documents or standards, none currently address the hydrogen sector. Renewable energy standards provide some guidance, but hydrogen is either minimally addressed or it is unclear to what extent it will be included. The EU CSRD and ESRS offer a comprehensive framework that clearly define sustainability aspects to be reported on.

While private frameworks are generally voluntary, certain jurisdictions have adopted the ISSB standards or have based their national standards on them, thereby moving toward mandatory implementation, including China (Deloitte, 2026). The EU is taking a different approach through the adoption of the EU CSRD and the ESRS. Generally, the GRI, ISSB, and TNFD frameworks have a high degree of alignment with the EU's ESRS, facilitating a streamlined reporting process that minimizes the burden of double reporting for global entities. For instance, the EU utilizes materiality definitions that align with the ISSB standards (EFRAG & IFRS, 2024), and organizations that report under the ESRS are considered to be reporting 'with reference' to the GRI (GRI & EFRAG, 2024). For the TNFD, all 14 TNFD disclosure recommendations are directly integrated into the ESRS (EFRAG & TNFD, 2024). Consequently, organizations utilizing these international standards may leverage their existing data to work towards compliance with European requirements. In light of the reduced scope of companies covered by the EU CSRD, these voluntary schemes may become even more relevant.

TABLE 14: ESG FRAMEWORKS RELEVANT FOR HYDROGEN

Governance Instruments	Type	Climate	Renewability	Environment	Social	Specific vs. Generic	Binding vs. Voluntary	Materiality	Scope
Equator Principles	ESG Frameworks for Managing Social and Environmental Risks			X	X	Generic: Financial Institutions for project financing	Voluntary	Double materiality*	Risk management framework for financial institutions, applicable to projects across sectors and jurisdictions.
Taskforce on Nature-related Financial Disclosures (TNFD)	ESG Disclosure and Reporting Standards			X	X	Generic: Applicable across multiple industries (no sector-specific guidance yet)	Voluntary	Double materiality	Integrate nature-related considerations into corporate reporting requirements of organizations across sectors and jurisdictions.
Global Reporting Initiative (GRI)	ESG Disclosure and Reporting Standards	X		X	X	Generic & applicable to any kind of business; sector standards exist, but not for hydrogen or renewable energies	Voluntary	Primarily impact materiality; prepares companies to consider financial materiality, too*	Enables organizations across all sectors and jurisdictions to produce sustainability reports to disclose information to investors, policymakers, consumers, etc.
ISSB & Sustainability Disclosure Standards (IFRS S1 and S2)	ESG Disclosure and Reporting Standards	X		X	X	Generic & applicable across any kind of business; sectoral guidance is available in areas like renewable energy, not for hydrogen.	Voluntary	Primarily financial materiality	The standards enable specific climate-related disclosures and general sustainability-related disclosures for organizations across sectors and jurisdictions.
EU CSRD and ESRS	Transparency & Disclosure Mechanisms	X		X	X	Generic	Binding for certain companies	Double materiality	Broad and comprehensive framework for clearly defined sustainability aspects. The CSRD serves as the overarching framework, while the ESRS operationalize its provisions
CSDS China	Transparency & Disclosure Mechanisms	X		X	X	Generic	Binding for certain companies	Double materiality	Sustainability impacts and risks covered depend on the materiality of a company's operations. Climate-focused standard available as a draft.

Source: Authors

*without using the explicit wording of the two different types of materiality.

9 High-Level Principles and Initiatives

Key Highlights for Hydrogen Sustainability

High-Level Principles (Generic)

- Various high-level principles support sustainable economic activities, guiding companies, multinationals, institutional investors, and governments on human rights, ESG integration, responsible business conduct, sustainable investment, and more.
- While these principles are voluntary, they can influence the sustainable scale-up of the hydrogen economy by serving as the basis for existing legislation or as global reference points, particularly the UN Guiding Principles on Business and Human Rights and the OECD Guidelines for Multinational Enterprises.
- Scope ranges from overarching principles to comprehensive frameworks, encompassing a wide diversity of sustainability dimensions.
- As sector-specific guidelines or supporting documentation are typically available, these may be developed for hydrogen in the future, too.

Hydrogen-specific Sustainability Initiatives

- In addition to generic frameworks and principles, three international initiatives in particular promote sustainable practices in the global hydrogen sector
- The United Nations Industrial Development Organization (UNIDO), through the Global Programme for Hydrogen in Industry (GPHI), supports sustainable hydrogen, particularly in emerging and developing economies, by providing training, technical assistance, and guidance, including the 'Guidelines for Sustainable Hydrogen Projects in Developing Countries' (2025).
- The International PtX Hub, funded by the German government, performs sustainability-related policy and regulatory advisory, capacity building, and organizing cross-sectoral stakeholder dialogues across multiple countries. The Hub also applies its own sustainability framework, covering economic, environmental, social, and governance dimensions (EESG framework), to guide its activities.
- The industry-led Green Hydrogen Organisation promotes sustainability through its standard, other knowledge products, and stakeholder engagement with a variety of actors, including convening the Roundtable of Development Finance Institutions for Green Hydrogen to help mobilize financing for projects in developing and emerging economies.

This chapter reviews high-level principles and other initiatives that support or influence the development of a sustainable hydrogen economy. It begins by presenting and comparing selected, widely referenced generic principles that may provide guidance for actors in the hydrogen sector. Subsequently, the chapter reviews international sustainability initiatives that are specific to the hydrogen sector.

9.1 High-Level Principles – Generic

As outlined in Chapter 2.5, high-level principles serve as guiding frameworks for integrating sustainability considerations into business strategies. This section presents the most prominent frameworks that support sustainable business conduct and may provide guidance for hydrogen-related activities.

The OECD Guidelines for Multinational Enterprises on Responsible Business Conduct constitute a comprehensive, multilaterally agreed framework. The UN Guiding Principles on Business and Human Rights (UNGPs) offer a holistic approach, with a particular emphasis on social dimensions of sustainability, while the UN Global Compact can be understood as a baseline framework, providing principles for responsible and sustainable business practices. Finally, the UN Principles for Responsible Investment (PRI) focus on the financial sector, promoting the integration of sustainability considerations into investment decisions and enhancing accountability.

OECD Guidelines for Multinational Enterprises on Responsible Business Conduct

The OECD Guidelines for Multinational Enterprises on Responsible Business Conduct are recommendations issued by governments to promote sustainable business practices and mitigate adverse impacts of corporate activities on people, the environment, and society. First adopted in 1976 as part of the OECD Declaration on International Investment and Multinational Enterprises, the Guidelines are implemented through National Contact Points (NCPs) and supported by the OECD Due Diligence Guidance, which provides practical tools for integrating the Guidelines into operations and supply chains. The Guidelines are regularly updated to reflect changes in the global economy, with the most recent 2023 revision expanding topic coverage, emphasizing due diligence, and strengthening NCP mandates (OECD, 2023, p. 3).

Sustainability Dimensions Covered (1) - Overview

The Guidelines take a multi-dimensional approach, requiring enterprises to comply with host-country laws, consider stakeholder interests, and meet additional sustainability expectations. Companies are expected to respect human rights, support sustainable development, conduct risk-based due diligence, prevent and address adverse impacts, ensure transparency, uphold good governance, and engage stakeholders. Participation in voluntary initiatives aligned with international standards is also encouraged. Enterprises should report on activities and sustainability impacts using recognized disclosure standards and proactively work to prevent environmental, social, and governance harms (OECD, 2023, p. 12 - 24).

NCPs support implementation by handling grievances, offering mediation, issuing recommendations, and following up on outcomes. They also promote the Guidelines and due diligence guidance through national-language resources, events, training, and policy support, including contributions to National Action Plans on Business and Human Rights (OECD, n.d.)

Sustainability Dimensions Covered (2) – Environmental Aspects

Enterprises are expected to manage operations to protect the environment, prevent and remediate harms, and advance sustainable development. The Guidelines address climate change, biodiversity loss, ecosystem degradation, deforestation, pollution, and waste management. Companies should establish environmental management systems, conduct risk-based due diligence, set measurable science-based targets, monitor performance, and report transparently. They are also expected to adopt cleaner and resource-efficient technologies, provide environmentally sound products, raise customer awareness, and equip workers and suppliers with environmental knowledge and training. Key priorities include climate mitigation and adaptation, biodiversity conservation, and responsible governance of natural resources, consistent with the Paris Agreement, the Convention on Biological Diversity, and the Sustainable Development Goals (OECD, 2023, p. 33 - 38).

Sustainability Dimensions Covered (3) – Human Rights and Social Aspects

The Guidelines require enterprises to respect human rights in all contexts, irrespective of local enforcement. Companies should avoid infringing rights, prevent and address impacts they cause or contribute to, and use leverage to mitigate impacts linked to their operations, products, or services through business relationships. They are expected to adopt a public human-rights policy, conduct supply-chain due diligence, and engage stakeholders, including vulnerable or marginalized groups. When harm occurs, remediation should be provided or facilitated through legitimate processes, including effective grievance mechanisms (OECD, 2023, p. 25 - 27). The approach aligns with the UN Guiding Principles on Business and Human Rights (BMWE, 2025). The Guidelines also address broader social issues such as anti-corruption measures and workers' rights, including freedom of association and union membership.

Hydrogen-Specific vs. Generic

The OECD Guidelines are generic and do not contain provisions specific to hydrogen. However, the OECD provides a range of supporting materials—commonly referred to as 'tools for practitioners'—including policy papers, guidance documents, and e-learning resources. These cover broad economic sectors such as mineral supply chains or finance, as well as thematic topics like climate change or stakeholder engagement in extractive industries. While there is no hydrogen-specific guidance, some publications reference hydrogen-related issues; for example, a policy paper on responsible business conduct for climate action highlights the need for energy companies to carefully site hydrogen and

electrolysis plants to avoid water-scarce areas and unintended emissions from energy-intensive adaptation measures like desalination (OECD, 2024).

Binding vs Voluntary

The OECD Guidelines are voluntary standards for responsible business conduct and are not legally binding. Instead, they offer recommendations on how enterprises can safeguard environmental and social concerns throughout their operations. NCPs play a central role in grievance handling, which may influence corporate adherence. The Guidelines also inform or align with international and national regulations, such as the EU Corporate Sustainability Due Diligence Directive (CSDDD).

Scope

The OECD Guidelines are a leading international instrument for responsible business conduct. All 38 OECD member countries and 14 non-OECD countries—including Germany, Chile, Argentina, Japan, and Tunisia—have formally adhered to them (OECD, 2023b). They primarily target multinational enterprises of all sizes, sectors, and ownership structures operating internationally.

UN Guiding Principles on Business and Human Rights (UNGPs)

Similar to the UN Global Compact (see above), the United Nations Guiding Principles on Business and Human Rights (UNGPs) provide a global framework outlining the responsibilities of both states and businesses with regard to human rights. Endorsed by the UN Human Rights Council in 2011, the UNGPs follow a three-pillar model of ‘protect, respect, and remedy’. Under this approach, states have a duty to protect individuals from human rights abuses by business enterprises operating within their jurisdiction. Business enterprises, in turn, are expected to conduct due diligence to identify, prevent, and address human rights abuses, both within their own operations and across their supply chains and business relationships. States must also ensure access to effective remedies for those affected by business-related human rights violations, including the responsibility to investigate, sanction, and resolve such harms (Bueno & Kaufmann, 2022).

Sustainability Dimensions Covered

The three-pillar model is operationalized through 31 principles, covering primarily social sustainability. The state duty to protect human rights (Principles 1–10) requires governments to prevent and address abuses through laws, regulations, and access to remedy. The corporate responsibility to respect human rights (Principles 11–24) obliges businesses to conduct due diligence, integrate human rights considerations into policies and processes, and provide or cooperate in remediation when harms occur. Due diligence should be risk-based, addressing impacts the enterprise may cause, contribute to, or be linked to through business relationships. Its scope and complexity should reflect the severity of potential impacts, the enterprise’s size, and operational context, and it should be an ongoing, adaptive process (Ruggie, 2011). The access to remedy pillar (Principles 25–31) ensures that both judicial and non-judicial mechanisms are available to victims and that remedies are effective, equitable, and transparent (UN. Office of the High Commissioner for Human Rights, 2011).

The UNGPs do not include environmental sustainability explicitly. However, in 2023, the UNHR Special Procedures Working Group published an informational note on ‘Climate Change and Guiding Principles on Business and Human Rights’ (UN, 2023). The document highlights that both states and business enterprises have obligations and responsibilities regarding climate-related human rights impacts. Under the state duty to protect, governments are called upon to implement ambitious NDCs, integrate human rights into climate policy, require human rights and environmental due diligence across value chains, and mandate disclosure of GHG emissions. Business enterprises must identify, prevent, mitigate and account for climate-related human rights impacts by integrating climate considerations into governance, due diligence, and stakeholder engagements, identify scope 1–3 emissions, phase out fossil fuels and ensure value chains are in line with the net-zero transition. Both states and businesses must ensure access to remedy for climate-related human rights harms (Climate Change and the UNGPs, 2023).

Hydrogen-Specific vs. Generic

The UNGPs are generic and sector-agnostic. Their relevance for the hydrogen sector arises due to the risks that hydrogen-related projects might pose, in terms of, for example, land acquisition, infrastructure construction, renewable energy deployment, and water use.

Thus, hydrogen projects may be required to conduct due diligence in accordance with the principles, as well as provide remediation in case of violations.

Binding vs Voluntary

The UNGPs are a voluntary framework that functions primarily as a global reference point, as they can be used as a blueprint for binding legislation. For example, the UNGPs form the basis for the EU CSDDD (Van den Berghe et al., 2024, p. 34, see Chapter 3.2 of this study), France's Duty of Vigilance Law (2017), which requires large French companies to implement human rights vigilance plans, and the Dutch Child Labour Due Diligence Law (2019), which mandates companies to identify and address child labor risks in their supply chains (Sherman, 2020).

The UN Working Group on Business and Human Rights has also urged states to implement the UNGPs through national action plans. As of November 2025, 35 countries have adopted such plans, including Germany, Chile, and the United States (OHCHR, 2025).

Scope

The UNGPs apply to all states and business enterprises, regardless of their size, ownership structure, sector, and geographic footprint. They cover the entire value chain, and require companies to assess impacts from their own operations, suppliers, contractors, joint ventures, and downstream relationships.

Beyond legislation, the UNGPs' human rights due diligence framework has influenced other international standards. The International Finance Corporation (IFC) incorporated due diligence principles in its 2012 revision of the Performance Standards, and the World Bank aligned its Environmental and Social Framework with the UNGPs in 2017 (Rasche & Waddock, 2021).

UN Global Compact

The UN Global Compact is a voluntary initiative that encourages companies to align their operations and strategies with ten (high-level) principles covering human rights, labor, environment, and anti-corruption. These principles are derived from widely recognized international frameworks, including the Universal Declaration of Human Rights, the ILO Declaration on Fundamental Principles and Rights at Work, the Rio Declaration on Environment and Development, and the United Nations Convention Against Corruption. By integrating these principles into their strategies and fostering a culture of integrity, companies uphold their responsibilities towards the UN Sustainable Development Goals (SDGs) and the Paris Agreement while creating a foundation for long-term success (Majerbi, 2023).

In practice, companies are required to produce an annual Communication on Progress (CoP), which serves as a public accountability mechanism. The CoP includes:

- *CEO Statement of Continued Support*: A declaration affirming the organization's ongoing commitment to the ten principles.
- *CoP Questionnaire*: A report detailing corporate actions and performance related to the ten principles and the Sustainable Development Goals (SDGs).

These reports are submitted through the UN Global Compact digital platform and are accessible to the public, allowing stakeholders to assess a company's sustainability efforts. Additionally, the UN Global Compact offers resources such as the CoP Guidebook and CoP Academy to assist companies in preparing their reports and improving sustainability performance (UN Global Compact, 2025b). With more than 25,000 organizations in 167 countries, the UN Global Compact is the largest corporate sustainability initiative globally, and also offers guidance, best practices, and networking opportunities (Majerbi, 2023; UN Global Compact, 2025a).

Sustainability Dimensions Covered

The UN Global Compact covers four broad sustainability dimensions – human rights, labor, environment, and anti-corruption. Within these areas, it establishes ten guiding principles that help businesses integrate sustainability into their strategies and operations. The initiative encourages companies to respect and protect human rights, uphold fair and safe labor practices, manage environmental impacts responsibly, and actively prevent corruption (UN Global Compact, n.d.). For example, the environmental principles (Principle 7-9) call on companies to support a precautionary approach to environmental challenges,

encourage development and diffusion of environmentally-friendly technologies, and undertake initiatives to promote greater environmental responsibility (ibid.).

Hydrogen-Specific vs. Generic

The UN Global Compact is general and does not contain any hydrogen-specific rules, criteria, or governance mechanisms. Its climate and sustainability principles are non-sector-specific and apply broadly across industries and technologies. The Compact does not define activities or thresholds related to hydrogen production, transport, or use.

Binding vs. Voluntary

The UN Global Compact Principles are voluntary, and do not impose legal restrictions. They have a guiding, rather than binding, character. However, failure to submit a Communication on Progress report (CoP) can result in removal from the initiative.

Scope

The UN Global Compact operates at the organizational level and is not limited to specific segments of the value chain. It focuses on corporate behaviour, policy engagement, and capacity building. As a global initiative, it is open to companies worldwide, which can participate through national Global Compact networks.

The UN Principles for Responsible Investment

The UN-supported Principles for Responsible Investment (PRI) is an investor-led global initiative that promotes responsible investment by encouraging the integration of environmental, social, and governance (ESG) considerations into investment and ownership decisions. Established in 2006, the PRI sets out six high-level principles that provide a framework for incorporating ESG issues into investment practice (Majerbi, 2023). The PRI may function as a strategic governance mechanism that guides institutional investors in embedding sustainability considerations into their policies, decision-making processes, and stewardship activities

Since its launch, the PRI has expanded to over 4,000 institutional investors—such as pension funds, banks, insurance companies, and asset managers—collectively managing more than USD 120 trillion in assets. Signatories are required to report annually on their responsible investment activities and to demonstrate a minimum level of ESG integration. For example, they must publish investment policies addressing ESG issues for at least 50% of their assets under management (UNPRI, 2020).

Sustainability Dimensions Covered

The initiative primarily focuses on the financial materiality of sustainability-related risks but increasingly encourages signatories to consider their contribution to broader sustainability outcomes (UNPRI, 2020).

The six principles cover the integration of ESG considerations into investment analysis and decision-making processes (Principle 1), as well as their reflection in ownership policies and practices (Principle 2). They include the expectation that investee companies provide appropriate ESG disclosures (Principle 3) and that the principles themselves are widely accepted and implemented (Principle 4). The framework also emphasizes collaboration to enhance the effectiveness of implementation (Principle 5) and the reporting of activities and progress in relation to the principles (Principle 6). These principles are accompanied by reporting requirements, which address adherence to the principles through 39 different indicators (PRI, 2025).

Hydrogen-Specific vs. Generic

The PRI is a generic framework, designed to be applicable to institutional investors across asset classes and sectors globally. It does not contain specific provisions for hydrogen. It applies to hydrogen projects when its signatories, such as banks, pension funds invest in hydrogen-related projects and companies. Organizations involved in hydrogen-related development are also part of this global initiative. For instance, KfW, the German development bank, is a PRI signatory and actively supports investments in hydrogen projects (KfW, 2025; Majerbi, 2023).

Binding vs Voluntary

The six principles are voluntary. However, signatories are required to report annually on their implementation and progress towards implementing the principles. Failure to meet these requirements may lead to de-listing.

Scope

The PRI is focused on the investor-level, and the stewardship activities of its participants. Its scope covers the entire portfolio of investments held by investors, requiring them to seek disclosures from portfolio companies. Geographically, it is a globally applicable initiative.

9.2 Synthesis of High-Level Principles

The four initiatives, UN Global Compact, UN Guiding Principles on Business and Human Rights (UNGPs), the OECD Guidelines for Multinational Enterprises on Responsible Business Conduct, and the Principles for Responsible Investment (PRI) share a common purpose of promoting responsible business conduct and sustainable development, yet they differ in focus, scope, and the way they guide organizations. Table 15 provides an overview of the different characteristics.

All four are voluntary frameworks providing high-level guidance rather than prescriptive operational rules. The UN Global Compact covers human rights, labor, environment, and anti-corruption through ten principles, whereas the UNGPs are more focused on social sustainability. The UNGPs are targeted towards both the state and business enterprises, and focus on human and labor rights, protection, and remediation for vulnerable groups. Additionally, the UNGPs may carry significant influence, serving as the foundation for numerous national and international human rights frameworks. The OECD Guidelines stand out for addressing the most comprehensive range of environmental and social issues, for their formal endorsement by over 50 countries, including all OECD members, and for institutionalizing key elements, such as grievance mechanisms, as an integral part of the framework. The PRI targets institutional investors, guiding the integration of sustainability considerations on a high level—particularly environmental, social, and governance factors—into investment decision-making and ownership practices.

A differentiation lies in how organizations are expected to demonstrate responsible conduct. Companies participating in the UN Global Compact are required to submit annual Communications on Progress, providing transparency about efforts to uphold the ten principles and contribute to global sustainability goals. Supporters of the UNGPs increasingly implement human rights due diligence processes and align internal policies with recognized international human rights standards. PRI signatories report on ESG integration and responsible investment practices, reflecting their role in steering capital toward sustainable outcomes. In contrast, enterprises adhering to the OECD Guidelines operationalize responsible business conduct across environmental, social, and governance dimensions, while governments provide oversight and grievance mechanisms through National Contact Points, creating a structured, state-backed framework for accountability. Both the UNGPs and the OECD Guidelines require due diligence based on the risks and severity of potential impacts.

Despite these differences, all four initiatives share a similar purpose: to provide a framework for embedding sustainability principles into strategy and decision-making, encourage accountability through reporting, and support organizations in contributing positively to global social, environmental, and governance objectives. In this sense, while each initiative targets different stakeholders and specific dimensions of sustainability, they collectively create a complementary ecosystem for advancing responsible business and investment practices globally.

TABLE 15: COMPARISON OF SELECTED HIGH-LEVEL PRINCIPLES

Name	Sustainability Dimensions Covered						
	Climate	Renewability	Environmental	Social	Specific vs. Generic	Binding vs. Voluntary	Scope
UN Global Compact	X		X	X	Generic	Voluntary	Any company across the value chain
UN Guiding Principles on Business and Human Rights (UNGPs)				X	Generic	Voluntary, with significant legislative influence.	States and business enterprises
OECD Guidelines for Multinational Enterprises on Responsible Business Conduct	X		X	X	Generic	Voluntary, with significant legislative influence.	Multinational enterprises
Principles for Responsible Investment (PRI)			X	X	Generic	Voluntary	Applicable to signatories from the financial market: asset managers, investment owners, and service providers.

9.3 Hydrogen-specific Sustainability Initiatives

In addition to the generic high-level principles outlined above, several international initiatives in support of the hydrogen sector explicitly target the promotion of sustainability in the sector. These initiatives typically address sector-specific challenges by combining policy guidance, capacity building, technical assistance, knowledge exchange, and more.

Global Programme for Hydrogen in Industry, UNIDO

The United Nations Industrial Development Organization (UNIDO) launched the Global Programme for Hydrogen in Industry (GPHI) in 2021, with support from the governments of Austria, Germany, and Italy. The program aims to support developing countries in addressing key barriers to hydrogen deployment while promoting a just transition that integrates environmental protection and social sustainability.

The GPHI encompasses a broad range of activities, including support for the development of policies, regulatory frameworks, standards, skills, and financing mechanisms. A central objective is to strengthen coordination among key stakeholders to enable the emergence of a just and sustainable hydrogen economy. These activities are delivered through knowledge products, training, and technical advisory services. The program is currently active in 14 countries, including Algeria, Brazil, Namibia, and South Africa (UNIDO, 2026).

A key output of the program is the development of knowledge products such as the 'Guidelines for Sustainable Hydrogen Projects in Developing Countries' (UNIDO, 2025). These guidelines provide a comprehensive framework to support policymakers and project developers in the planning, assessment, and approval of large-scale renewable hydrogen projects, with a strong emphasis on environmental and social risk mitigation.

The framework is structured around four core pillars, each defined by specific subtopics and criteria to guide sustainable project development:

- **People:** promoting robust labour and social standards. For example, developers are expected to conduct due diligence before granting permits, allocating land, or providing financial support.
- **Planet:** safeguarding water resources and minimizing environmental impacts. Hydrogen projects should ensure water use does not compete with local needs, enhance local water availability and affordability, and conduct early-stage water risk and impact assessments with transparent communication to local authorities and communities.
- **Prosperity:** Fostering local value creation and sustainable financing. For example, international developers of large-scale projects shall establish concrete plans for collaboration with local firms to facilitate technology transfer, knowledge sharing, and capacity building.
- **Provision of renewable energy:** Ensuring efficient and equitable energy allocation. Projects should dedicate a significant part of the generated

International PtX Hub, GIZ

The International Power-to-X (PtX) Hub is an international platform for knowledge exchange and collaboration, funded by the German government and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The Hub plays a central role in fostering legitimacy, coordination, trust, and the development of a sustainable PtX economy. It supports countries and industries in understanding how PtX technologies can be deployed efficiently and sustainably, aligned with long-term climate objectives. The Hub serves as a center for knowledge, collaboration, and innovation along the PtX value chain. Primary areas of focus in the PtX Hub's work include:

- **Policy and regulatory advisory:** The hub advises on the development of effective strategies, policies, and regulations to scale-up green hydrogen in a variety of countries, such as Argentina, Chile, Kenya, and many others.
- **Capacity development:** Through the PtX Academy, it provides training on the technology and economics of PtX through basic training, and 'training of trainers' programs. It provides modules for political stakeholders, as well as for project finance practitioners. Some topics covered include sustainability, aviation, shipping, power-to-chemicals, certification schemes, project finance, green steel, PtX CBAM, and green ammonia and fertilizers. In addition, the Hub publishes a wide range of knowledge products—including reports and studies—to enhance expertise and understanding.
- **Cross-sectoral stakeholder dialogues:** The Hub convenes policymakers, project developers, civil society, and investors to explore how PtX can advance climate action, while also facilitating connections between investors and relevant projects.

As part of its activities, the PtX Hub developed the EESG framework to promote sustainability in hydrogen projects (International PtX Hub, 2022). The framework addresses four key dimensions:

- **Environmental:** Encourages the use of renewable electricity meeting additionality criteria, while avoiding contributions to water stress, biodiversity loss, and unsustainable land use.
- **Economic:** Projects should align with national energy transition strategies, support technology and knowledge transfer, and avoid negative impacts on local energy systems.
- **Social:** Projects are expected to respect human and labor rights, ensure local access to energy and water, and promote job creation while mitigating potential job losses through reskilling and training.
- **Governance:** Emphasizes strong governance practices, including certifications, stakeholder engagement, transparency, and robust communication.

The EESG framework is also applied directly in a specific government funding mechanism, the International Hydrogen Ramp-Up Program (H2Uppp). H2Uppp is a project funded by the former German Federal Ministry for Economic Affairs and Climate Action (BMWK) and implemented by GIZ under the International PtX Hub. It aims to accelerate the development of green hydrogen and Power-to-X markets in emerging and developing economies, particularly in the Global South. Through project identification, support for the development of early-stage projects, and the facilitation of trade partnerships for hydrogen and its derivatives, the program promotes sustainable hydrogen value chains and international partnerships (AWE, n.d.; BMWK, 2025).

Green Hydrogen Organisation

Another prominent example is the Green Hydrogen Organisation and its activities. Of particular importance is its Green Hydrogen Standard, which establishes a comprehensive

sustainability framework specifically developed for green hydrogen and its derivatives (see Chapter 7.1). Alongside this standard and certification scheme, the organization is an active player in promoting hydrogen sustainability through a range of activities, including roundtables, the publication of reports and knowledge products, and initiatives such as the Green Iron Principles (GH₂, 2025). The organization also engages with a wide range of stakeholders, including corporations, financial institutions, and governments across different regions worldwide. One particularly important initiative is the Roundtable of Development Finance Institutions for Green Hydrogen. This platform facilitates dialogue among international financial institutions, multilateral development banks, and development actors on how to scale up support for renewable energy and green hydrogen production in developing and emerging economies. Participating institutions include, among others, the African Development Bank, the Asian Development Bank, the Asian Infrastructure Investment Bank, British International Investment, BNDES, the European Bank for Reconstruction and Development, the European Investment Bank, KfW, the Inter-American Development Bank, and IFC (GH₂, 2022a).

10 Synthesis of Results and Policy Implications

This final chapter provides a brief review of the main results of the study and discusses a number of implications for policy. It begins by providing an overview of key elements of the sustainability governance landscape. It then provides a brief comparative analysis of sustainability governance in the European Union, China, and the United States, as well as the main standards, regulatory thresholds, and certification schemes for measuring the impact of hydrogen production on GHG emissions. Finally, it identifies a number of entry points and recommendations to strengthen sustainability governance in the hydrogen sector.

10.1 Categorization of Governance Elements by Sustainability Dimensions and Hydrogen Specificity

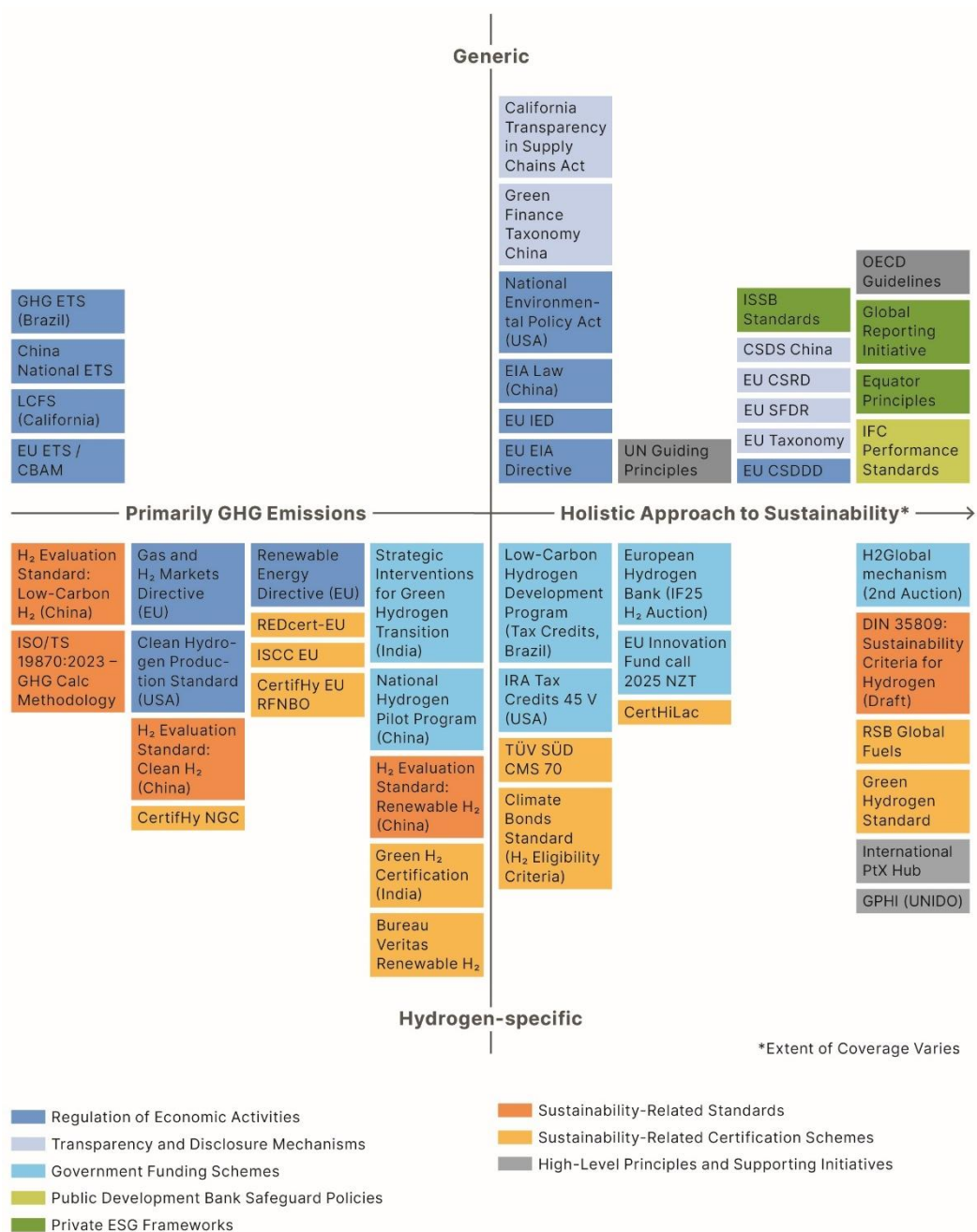
Building on the elements outlined in the previous chapters, figure 4 provides a mapping of the main governance mechanisms that promote or influence the sustainability of the hydrogen sector. It shows that a range of generic governance instruments adopts a multi-dimensional sustainability approach (upper-right quadrant). Although these instruments are not tailored to the hydrogen sector, they can play an important role in promoting sustainability in the sector. Key examples are found in EU regulations, including the EU CSDDD, sustainability-disclosure regimes like the CSRD, the SFDR, alongside well-established environmental legislation.

Similarly, financial institutions integrate generic due diligence requirements for ESG-related aspects. The most stringent requirements are applied by multilateral development banks, such as the World Bank's International Finance Corporation (IFC). In the private sector, ESG frameworks like the Equator Principles and the ISSB Standards, as well as high-level principles like the OECD Guidelines for Multinational Enterprises on Responsible Business Conduct, are important reference points.

Alongside these generic instruments, a variety of hydrogen-specific governance mechanisms have emerged. Many of these focus on GHG-related requirements (lower-left quadrant). This includes legislative packages such as the EU Renewable Energy Directive (RED), a number of certification systems (at the global and national levels), and hydrogen-specific GHG emission calculation methodologies, like ISO/TS 19870.

Finally, a number of hydrogen-specific instruments take a broader approach (lower-right quadrant). These include initiatives in support of hydrogen, like UNIDO's Global Programme for Hydrogen in Industry, the International PtX Hub, as well as the Green Hydrogen Organisation. UNIDO and the International PtX Hub have developed guidelines and frameworks for promoting sustainability in the hydrogen sector and integrating this in country-level capacity building. The Green Hydrogen Organisation has launched its Green Hydrogen Standard along with a corresponding certification scheme. Other certification schemes with a broader approach to sustainability include the Roundtable on Sustainable Biomaterials 'Global Fuels' scheme, the Climate Bonds Standard with its Hydrogen Eligibility Criteria, and, to a more limited extent, the TÜV SÜD CMS70 Certification and the CertHiLac scheme (currently under development). However, the application of these certification schemes remains very limited. In Germany, a draft sustainability standard for hydrogen has been developed within the framework of its national standardization body, which might serve as a reference point for certifications in the future. Alongside certification schemes, sustainability requirements are integrated within public funding mechanisms like the EHB or the H2Global Mechanism, which has the most elaborate sustainability requirements so far.

FIGURE 4: CATEGORIZATION OF SUSTAINABILITY GOVERNANCE MECHANISMS IN THE HYDROGEN SECTOR



Source: Authors.

NB: The horizontal axis indicates the extent to which elements incorporate broader environmental and social sustainability dimensions, while the vertical axis distinguishes between generic and hydrogen-specific governance approaches. Generally, the further to the right an element is positioned, the more sustainability dimensions it covers. The figure provides a schematic, illustrative overview and does not capture differences in how individual elements address specific dimensions (e.g., some focus solely on environmental aspects, others only on social considerations). The vertical positioning conveys no additional meaning.

10.2 Comparative Analysis across the EU, U.S. and China

Governmental approaches to ensuring the sustainability of hydrogen vary considerably across the European Union, the United States, and China. While all three jurisdictions have been investing in hydrogen as a cornerstone of decarbonization and industrial policy, their regulatory, policy, and funding mechanisms differ in scope, orientation, and emphasis. The comparison reveals substantial divergence in how sustainability is defined and operationalized, alongside some emerging points of convergence. Tables 16 – 18 below present a comparative overview of regulatory and policy approaches to hydrogen sustainability in the European Union, the United States, and China, structured according to the four sustainability dimensions considered throughout this study: climate,

renewability, environmental, and social impacts. They highlight how and to what extent sustainability considerations are embedded within the respective governance mechanisms in the three jurisdictions.

European Union

The EU has developed the most comprehensive governance architecture for hydrogen sustainability, in many cases via generic instruments that do not exclusively target the hydrogen sector. The Renewable Energy Directive (RED) and its delegated acts, together with the EU Hydrogen and Gas Decarbonisation package, constitute the only hydrogen-specific regulation with binding sustainability provisions. However, their scope is confined to climate-related and renewability aspects. In particular, the RED includes stringent requirements for ensuring that so-called renewable fuels of non-biological origin (RFNBOs) exclusively utilize electricity from additional renewable energy capacities, built with the explicit aim of powering renewable hydrogen production.

Beyond these two legislative packages, sustainability is embedded through broader EU regulatory instruments. Hydrogen projects at an industrial scale are subject to the Environmental Impact Assessment (EIA) Directive, which introduces both environmental safeguards and stakeholder participation elements. For projects receiving EU funding, additional requirements apply through the “Do No Significant Harm” (DNSH) criteria of the EU Taxonomy. This applies to funding through the European Hydrogen Bank, and more generally, through the EU Innovation Fund (which also has hydrogen funding streams). The EHB has further tied funding eligibility to compliance with RFNBO criteria, though its latest auction extended its scope to low-carbon hydrogen.

The EU also supports hydrogen sustainability indirectly through transparency, disclosure, and due diligence frameworks that address sustainability risks and impacts. The SFDR and CSRD require financial actors and companies to report on sustainability issues, aiming to guide investments. Complementing these disclosure obligations, the CSDDD requires companies to actively identify, prevent, and address adverse human rights and environmental impacts across their value chains. Although not hydrogen-specific, these frameworks establish sustainability requirements along the hydrogen value chain, including producers, purchasers, and investors.

Overall, the EU framework is notable for its regulatory breadth and alignment of funding, permitting, and disclosure mechanisms. Its hydrogen-specific elements focus on climate and renewability aspects, while broader environmental and social dimensions are addressed via generic instruments. Additionally, many existing sustainability governance frameworks in the form of legislation have undergone revisions or are scheduled for revision in 2026. While the relevant legislation—EU CSDDD, CSRD, ESRS, EU Taxonomy, SFDR, EIA Directive, and Industrial Emission Directive (IED)—remains in force, the scope and/or content are, in certain areas, subject to substantial reductions. For instance, the number of companies directly subject to the CSRD and CSDDD has been significantly narrowed, several sustainability provisions in the CSDDD have been curtailed, and the ESRS, which operationalize the CSRD, are currently being simplified. The Commission has also published proposals to simplify the SFDR, EIA Directive, and IED (see Chapters 3.2–3.4 and 3.5 for further details).

United States of America

In the U.S., federal policy introduced under the Biden administration has focused primarily on accelerating deployment and ensuring economic competitiveness through large-scale investments. The Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) provide the backbone of this approach, including tax credits under Section 45V (up to \$3/kg hydrogen) and substantial federal funding for seven regional Clean Hydrogen Hubs.

Sustainability considerations are incorporated primarily through climate-related provisions. The most prominent example is a state-level scheme. California’s Low Carbon Fuel Standard (LCFS) requires hydrogen to become fully renewable by 2035, making it the only U.S. regulation with a binding future requirement for renewable hydrogen. Environmental safeguards are applied through the generic National Environmental Policy Act (NEPA), which mandates environmental assessments for federally funded or permitted projects.

Social dimensions are partly integrated into federal funding schemes. The Clean Hydrogen Hubs program incorporates environmental justice criteria, and the IRA tax credits include labor standards. That said, several measures to support hydrogen production have been withdrawn or are under review by the current U.S. administration. For example, certain funding allocations for the Hydrogen Hubs have been cancelled. The 45V tax credit

mechanism remains in effect in principle, although the deadline to start construction has been shortened to the end of 2027, strongly limiting its impact.

China

China's governance of hydrogen is closely tied to its broader industrial and strategic priorities: technological leadership, energy security, and decarbonization. More recently, China's commitment to renewable hydrogen has assumed increased visibility. For example, certain state-owned enterprises have been mandated to pursue renewable hydrogen projects under the Green Low-Carbon Advanced Technology Demonstration (GLATD) program, even where projects are not financially viable.

A significant recent development is the introduction of the Clean and Low-Carbon Hydrogen Evaluation Standards, showing increasing international alignment. These standards define thresholds for GHG emissions across hydrogen production pathways and also establish criteria for hydrogen produced with renewable electricity. Compared with earlier schemes, these standards mark a shift toward regulatory consolidation and greater alignment with international practices. Compliance with these standards may become a prerequisite for major government funding or other governance schemes such as GLATD or the National Hydrogen Pilot Program. The latter provides long-term loans from the Chinese government for a wide range of projects across the hydrogen value chain - including, but not limited to, renewable hydrogen production.

China has also introduced sustainability disclosure and green finance frameworks, including the Corporate Sustainability Disclosure Standards (CSDS), aligned with the internationally recognized ISSB Standards, and a Green Taxonomy. The latter explicitly features a variety of hydrogen-specific activities. While structurally similar to the EU's instruments, China's taxonomy does not yet include explicit social safeguards. Broader sustainability dimensions—such as biodiversity, land and water use, or social equity—are not substantively integrated into hydrogen-specific governance and remain addressed primarily through general environmental law.

Overall, China's approach to hydrogen governance reflects a dual logic: strong industrial and security-driven priorities, alongside an increasing focus on renewable hydrogen. The result is an evolving framework that is increasingly harmonized with international approaches, but still narrow in its treatment of wider environmental and social sustainability concerns.

Comparative Assessment

Despite regional variation, no jurisdiction has developed a fully integrated regulatory framework dedicated exclusively to the environmental and social sustainability of hydrogen. Instead, all three rely on governance models that combine direct market-support measures with indirect safeguards through broader environmental and social regulations.

- **Regulatory approach and focus:** The EU has the most comprehensive regulatory regime, embedding sustainability across permitting, funding, and corporate reporting. The U.S. framework is largely incentive-driven and fragmented. Both the EU and the U.S. have seen some reductions in terms of the stringency of sustainability governance. China's framework is evolving, combining state-led industrial policy with a growing focus on renewable hydrogen and an increasing alignment of related standards.
- **Focus on climate and renewability:** Climate and GHG emission considerations dominate across all three regions. The EU has developed a stringent policy to support the uptake of renewable hydrogen in EU Member states. If production is to be counted toward the EU's renewable hydrogen targets (i.e. RFNBOs), these have to ensure that these are powered by newly built renewable energy capacities. China has codified GHG thresholds and increasingly focuses on renewable hydrogen, while the U.S. uses a tiered system (depending on GHG emission intensity) for providing tax credits through the IRA.
- **Broader sustainability aspects:** Additional sustainability aspects are primarily addressed through generic governance instruments. The EU Corporate Sustainability Due Diligence Directive (CSDDD), which addresses supply chain sustainability, is a unique mechanism within the EU to ensure sustainability risks are managed along supply chains, including those incurred by potential suppliers outside the EU.
- **Transparency and disclosure:** The EU also leads with its EU Sustainable Finance Disclosure Regulation (SFDR), which requires financial market participants to disclose sustainability-related risks and impacts of investment products. The EU Taxonomy also contributes by defining, which activities can be considered environmentally sustainable. They can indirectly support hydrogen sustainability by guiding investment

toward low-carbon or renewable hydrogen projects that minimize environmental harm and meet minimum social safeguards. Similar initiatives are also emerging in China.

- **Certification schemes and standards:** The EU's certification system under RED is the most advanced. China is moving toward standardization through its Clean and Low-Carbon Hydrogen Evaluation Standards. The U.S. lacks a comparable certification system, relying instead on financial incentives tied primarily to carbon intensity. Certification schemes and standards covering sustainability more broadly are not part of the regions' legislative regimes.
- **Funding mechanisms:** The EU combines auctions (European Hydrogen Bank, EU Innovation Fund) with sustainability conditions. The U.S. relies on tax credits and grants, with some limited requirements towards social sustainability. China mobilizes state-owned enterprises and loan schemes that apply climate- and renewability-focused criteria.
- **Social dimensions:** The EU incorporates social safeguards in the CSDDD, and to a lesser extent, in its Taxonomy, while the U.S. has linked IRA tax credits to labor provisions. China has not substantively integrated social considerations into hydrogen-specific frameworks. Environmental regulations, existing across all three regions, typically require stakeholder processes.

In conclusion, the EU has established a comprehensive sustainability governance framework, although recent adjustments to its scope and content are underway. Within this framework, hydrogen-specific governance remains predominantly oriented toward climate mitigation. The U.S. prioritizes rapid deployment and competitiveness, embedding only minimal safeguards (and with strong indications that state support for hydrogen will be scaled back), while China is increasingly converging with international standards on climate and renewability.

TABLE 16: REGULATIONS OF ECONOMIC ACTIVITIES IN THE EU, THE U.S. AND CHINA

Region	Renewability	Climate	Environment	Social	Relevance and Remarks
Regulations of Economic Activities					
EU	RFNBO Targets (that include and promote renewable hydrogen): No strict mandate; only relevant if contributing to RFNBO goals (10 Mt by 2030).	EU RED Delegated Acts: Specify GHG calculation methodology and threshold (≤ 3.38 kg CO ₂ e/kg H ₂) for RFNBO-hydrogen. The EU hydrogen and gas decarbonization package to define rules for low-carbon hydrogen (same thresholds as for RFNBO-hydrogen) EU ETS & CBAM: Apply carbon pricing and reporting requirements, depending on company size and sector.	General EU environmental regulations (EIA Directive): Apply to all industrial-scale hydrogen facilities. CSDDD: Although the revised directive significantly reduced sustainability provisions, it continues to serve as the primary framework for managing environmental and social risks in supply chains.	Indirect approaches: Risk mitigation via Supply Chain Due Diligence Act (CSDDD); effectiveness for hydrogen yet to be demonstrated. Although the revised directive significantly reduced sustainability provisions, it continues to serve as the primary framework for managing environmental and social risks in supply chains.	CSDDD underwent a major revision, significantly reducing the number of companies in scope and adopting a more general risk-based approach that targets only the areas where impacts are most severe and likely to occur. Simplifications for the EIA Directive and the IED are scheduled for 2026. RFNBO: Compliance via recognized voluntary certification schemes. EU ETS & CBAM: Annual monitoring and reporting; review by national authorities. EU Taxonomy: External auditing; oversight by national competent authorities and EU institutions. CSDDD: Enforcement by national authorities.
USA	Limited focus: Primarily regional (e.g., California LCFS), covering most transportation fuels sold in the state, with some exemptions; gradual phase-out of fossil-based fuels through 2035.	Regional Hydrogen Hubs: Must align with the Clean Hydrogen Production Standard (CHPS, BIL), but DOE may select projects below the CHPS threshold if they clearly support decarbonization goals as in the CHPS; full CHPS compliance still may receive preferential consideration. Target of ≤ 4.0 kg CO ₂ e/kg H ₂ but used more like a guideline.	Covered by the generic environmental regulation (NEPA).	Justice40 Initiative: was aimed to ensure $\geq 40\%$ of benefits from key federal investments (clean energy, climate resilience, housing) reach disadvantaged communities historically underinvested or overburdened; implementation slashed under the Trump administration. H2 Hubs: requires the development of community benefits plans (though funding for these are discontinued or under threat).	
China	Partly addressed in the Clean and Low-Carbon Hydrogen Evaluation Standard which defines “renewable hydrogen” as a distinct category with a stringent GHG threshold (see next column). More specific requirements details yet to be published. State-mandated projects to build-up electrolysis capacity (GLATD program)	State-mandated projects to build-up electrolysis capacity; thresholds under standard — Renewable H ₂ ≤ 2 kg CO ₂ e/kg, Clean H ₂ ≤ 3.86 kg, Low-Carbon H ₂ ≤ 13.23 kg (see left column); additional regulation via ETS for power producers emitting > 26 kt CO ₂ /year.	Addressed through generic environmental regulations	Stakeholder involvement is integrated into certain environmental regulatory procedures.	Oversight mainly by national and regional authorities; ETS includes mandatory MRV obligations for companies

Source: Authors

TABLE 17: TRANSPARENCY AND DISCLOSURE MECHANISMS IN THE EU, THE U.S. AND CHINA

Region	Renewability	Climate	Environment	Social	Relevance and Remarks
Transparency and Disclosure Mechanisms					
EU	/	<p>EU Taxonomy: “Substantial contribution” criteria for hydrogen in climate change mitigation; 3 kg CO₂e/kg H₂ threshold.</p> <p>CSR: Mandatory reporting of Scope 1–3 GHG emissions.</p> <p>SFDR: Scope 1–3 GHG disclosure requirements.</p>	<p>EU Taxonomy: DNSH criteria apply to hydrogen producers and importers.</p> <p>CSR: Reporting on four environmental areas, incl. biodiversity.</p> <p>SFDR: Disclosure of 14 mandatory environmental indicators, e.g., water pollution, biodiversity.</p>	<p>EU Taxonomy: Minimum social safeguards for hydrogen producers and importers.</p> <p>CSR: Reporting on four social dimensions, e.g., forced labor, working hours.</p> <p>SFDR: Disclosure of 14 mandatory social indicators, e.g., gender pay gap and inequalities.</p>	<p>Taxonomy: Classification system; voluntary in principle, but large firms/financial actors must report alignment (e.g., DNSH);</p> <p>CSR: Mandatory sustainability reporting under ESRS (Depending on a company’s materiality); Sustainability coverage may be reduced through a new delegated act to be published by September 2026 (ESRS).</p> <p>SFDR: Disclosure duties for financial market participants (Art. 8/9 funds); supervised by national financial regulators. A revision proposal was published by the European Commission in November 2025.</p>
USA	/	<p>CHPS provides a reference and emission target for hydrogen producers, enabling comparison of GHG intensity across producers.</p>	/	<p>Limited: applies only regionally (California Transparency in Supply Chains Act) and addresses human trafficking and slavery in supply chains.</p>	<p>CHPS: Non-binding; emissions calculated using a well-established federal model.</p> <p>California Transparency in Supply Chains Act: Companies with global revenues >\$100M doing business in CA must publicly disclose efforts on human trafficking and slavery; no financial or criminal penalties.</p>
China	/	<p>Hydrogen production shall contribute to climate change mitigation and adaptation.</p>	<p>Corporate Sustainability Disclosure Standards (CSDS), aligned with ISSB standards but based on a double materiality approach</p> <p>Green Finance Taxonomy: Requires not to cause harm to environmental objectives: environmental protection (e.g., ecological conservation), and efficient resource use</p>	<p>Corporate Sustainability Disclosure Standards (CSDS), aligned with ISSB standards but based on a double materiality approach</p>	<p>Taxonomy: Mandatory for all green finance instruments (credit, bonds, funds, insurance) from Oct 1, 2025; limited details on requirements; hydrogen activities should reduce GHGs and avoid harm to other environmental objectives.</p> <p>CSDS: Indirectly applies to actors along the hydrogen value chain; mandatory reporting initially for listed/large companies, extending to smaller/non-listed firms from 2030.</p>

Source: Authors

TABLE 18: GOVERNMENT FUNDING SCHEMES IN THE EU, THE U.S. AND CHINA

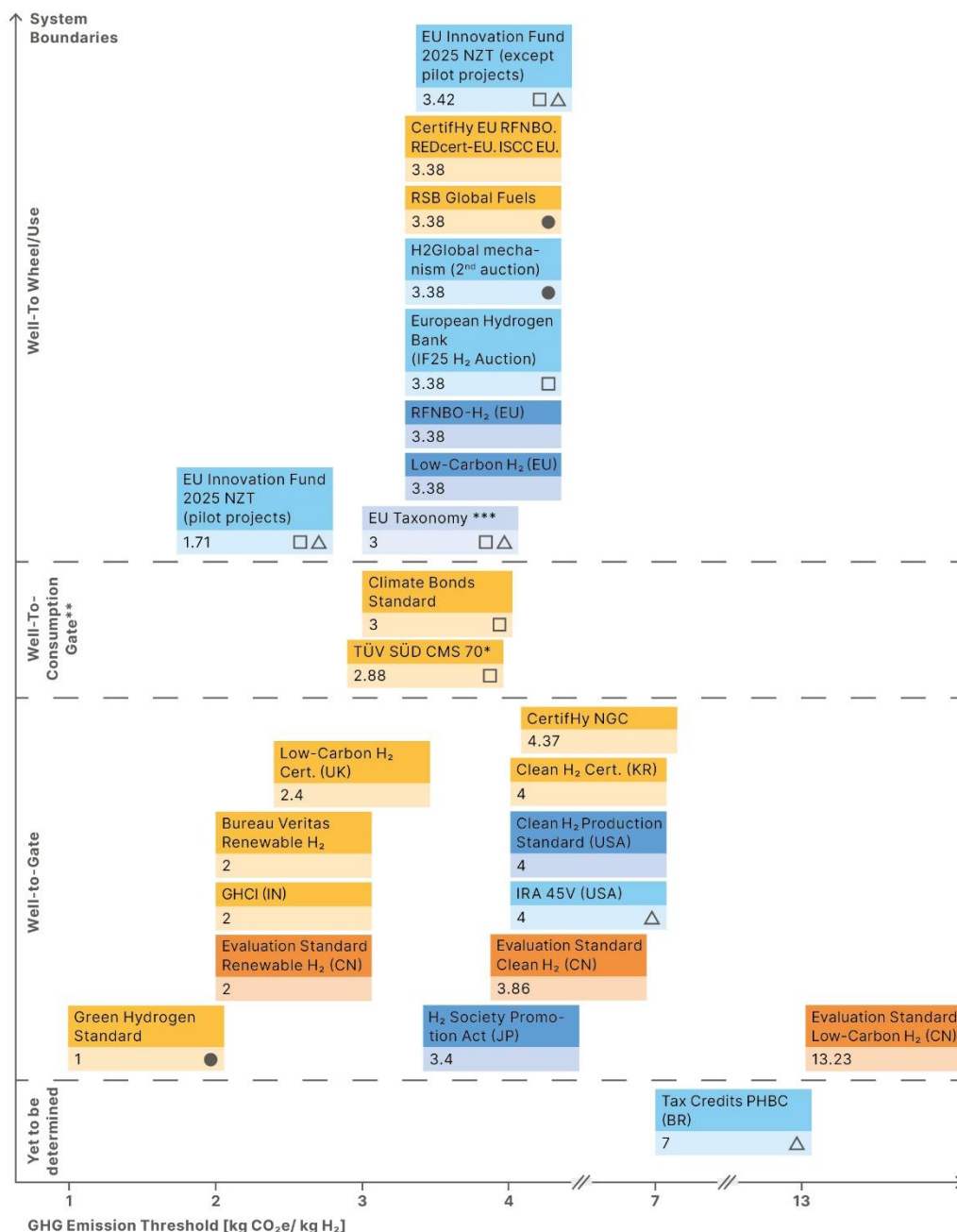
Region	Renewability	Climate	Environment	Social	Relevance and Remark
Government Funding Schemes					
EU	RFNBO/renewable hydrogen is not universally mandatory for EU funding schemes, but remains in focus in the latest auction of the European Hydrogen Bank (IF25 H ₂ Auction)	EU Funding Schemes: Compliance with stringent emission thresholds is required, with specific values depending on the project type and funding mechanism, ranging from 1.71 kg CO ₂ e/kg H ₂ for pilot projects under the EU Innovation Fund (2025 NZT Call), to 3.38 kg CO ₂ e/kg H ₂ under the European Hydrogen Bank, and 3.42 kg CO ₂ e/kg H ₂ for other EU Innovation Fund projects (2025 NZT Call).W	EU Funding Schemes: Adherence to DNSH criteria (as in EU Taxonomy) is required for funding through the EHB and the Innovation Funding, or projects may likely become ineligible anyway, if not fulfilled (IPCEI).	Due diligence measures are taken into account positively in the Innovation Fund's evaluation procedure.	
USA	/	Covered under IRA 45V Tax Credit; credits tiered from ≤0.45 kg CO ₂ /kg H ₂ up to 4 kg CO ₂ /kg H ₂ .	/	IRA 45V Tax Credits include some mandatory social requirements to be fulfilled, e.g., to provide wages meeting or exceeding locally prevailing wage rates and to fulfill apprenticeship quotas.	IRA tax credits for hydrogen tiered by GHG intensity to incentivize low-emission hydrogen; projects must begin construction by end of 2027.
China	Addressed by China's National Hydrogen Pilot Program via government-backed long-term loans and regional financial support for green hydrogen production.	Covered by the National Hydrogen Pilot Program through the same financial support mechanisms; may align with the hydrogen evaluation standard.	/	/	Limited information on specific requirements is available

Source: Authors

10.3 GHG Emission Thresholds and System Boundaries: Global Variations

Figure 5 provides a classification of the EU governance schemes analyzed in this study, highlighting their respective GHG emission thresholds and the system boundaries that they apply. The schemes considered include sustainability-related certification systems and GHG-focused certification schemes (Chapter 7), as well as governance instruments and thresholds derived from regulatory frameworks, transparency and disclosure mechanisms, and government funding programs.

FIGURE 5: CLASSIFICATION OF GOVERNANCE SCHEMES ACROSS GHG EMISSIONS AND SYSTEM BOUNDARIES



- Regulation of Economic Activities
- Transparency and Disclosure Mechanisms
- Government Funding Schemes
- Sustainability-Related Standards
- Sustainability-Related Certification Schemes
- Additional social & environmental dimensions (holistic approach)
- Additional environmental dimension (limited extent)
- △ Additional social dimension (limited extent)
- * Alternatively, a well-to-gate system boundary can be used. The threshold applies to heat, cooling, and steam applications, while a value of 3.38 applies to other hydrogen applications.
- ** ISO/TS 19870:2023 and IPHE use this approach
- *** While the EU Taxonomy permits alternatives, preference should be given to this system boundary

Source: Authors

Several observations emerge from this comparison. First, GHG emission thresholds are applied across different types of sustainability governance mechanisms. These include certification schemes, standards (such as China’s Clean Hydrogen Evaluation Standard, which may evolve toward regulatory status), thresholds linked to public funding programs, and thresholds embedded within regulatory or disclosure requirements.

Second, there are substantial differences in both the absolute GHG thresholds and the system boundaries applied. For example, China’s Clean Hydrogen Evaluation Standard sets a threshold of 3.86 kg CO₂e/kg H₂ using a well-to-gate system boundary, whereas many EU-focused schemes adopt a similar threshold (3.38 kg CO₂e/kg H₂) but apply a broader system boundary (well-to-wheel), encompassing a larger portion of the value chain. Such differences complicate direct comparisons of emissions and governance schemes, as narrower boundaries inherently omit some emission sources. Moreover, it should be noted that instruments with the lowest thresholds of 1 to 2 kg CO₂e/kg H₂ typically adopt the narrowest system boundaries. Overall, this analysis highlights the current lack of harmonization across hydrogen governance instruments, both in terms of emission thresholds and system boundary definitions.

Third, the lack of harmonization is further exacerbated by inconsistent terminology across instruments (see also Table 13, Chapter 7.2), with terms such as “green hydrogen,” “renewable hydrogen,” “clean hydrogen,” and “low-carbon hydrogen” referring to different emission thresholds.

Fourth, there are significant international discrepancies. The EU RED defines an emissions threshold (3.38 kg CO₂e/kg H₂) that is not fully aligned with the EU Taxonomy threshold of 3 kg CO₂e/kg H₂. The United States has established an upper-limit value for eligibility under tax incentives, while China’s thresholds range broadly—from 2 kg CO₂e/kg H₂ for benchmarking purposes to over 13 kg CO₂e/kg H₂ for low-carbon hydrogen. Among global schemes, the Green Hydrogen Standard and its certification Scheme stands out with the most ambitious threshold of 1 kg CO₂e/kg H₂.

10.4 Supporting Sustainable Hydrogen Ramp-Up: Implications for Policy

The findings of this study demonstrate that a wide array of governance mechanisms exists across major jurisdictions with the objective of facilitating and promoting a sustainable hydrogen ramp-up. These mechanisms differ significantly in terms of the sustainability dimensions they cover, their voluntary or mandatory nature, and whether they directly target the hydrogen sector or whether they influence the hydrogen sector directly or indirectly as generic sustainability governance mechanisms. Based on these findings, we derive a number of specific actionable recommendations.

Development of Hydrogen-Specific Guidelines for Sustainability-Related Due Diligence

The results of this study indicate that a range of generic instruments already exist to promote sustainability. Key examples include environmental and social policies of multilateral development banks—such as the IFC Performance Standards—which serve as generic frameworks for application across different types of projects and as reference points for other governance mechanisms. Similarly, ESG frameworks such as the Equator Principles help promote sustainability by providing a framework for sustainability-related due diligence in the financial sector. Most recently, the EU has added the Corporate Sustainability Due Diligence Directive (CSDDD), which obliges companies of more than 5000 employees in the EU to take responsibility for environmental and social risks along their supply chains.

To ensure that the potential of these generic governance instruments is fully realized, hydrogen-specific guidelines for due diligence procedures could play an important role. Such sector-specific guidelines would be particularly useful if they dovetailed with existing ESG frameworks and standards, while specifying the specific challenges of hydrogen-related investments. A number of existing frameworks and approaches are paving the way for such sector-specific guidelines. The Inter-American Development Bank’s technical note ‘Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean’ and the ‘Guidelines for Sustainable Hydrogen Projects in Developing Countries’, developed by UNIDO, represent important efforts in this direction. The Green Hydrogen Standard and its certification scheme, promoted by the Green Hydrogen Organization, provides important guidelines and experience in testing its application in

practice. Both could provide the foundation for the formal sector-specific guidelines required to meet the standards of mechanisms such as the Equator Principles or the CSDDD.

A joint effort by the major multilateral development banks and key private finance institutions to further develop such guidelines could help establish a global reference for sustainability-related due diligence in the hydrogen sector. Jointly developed guidelines would not only support sustainability efforts by private sector actors, they would also support the harmonization of due diligence requirements being established by governments and financial institutions. The World Bank's Energy Sector Management Program or a similar knowledge hub at one of the multilateral development banks would be a suitable actor to lead such an initiative, while the Roundtable of Development Finance Institutions for Green Hydrogen, coordinated by the Green Hydrogen Organisation, could function as a forum for related discussion and alignment.

Development of an ISO Standard as an International Reference for Sustainable Hydrogen

Complementing the development of sector-specific guidelines, the development of an ISO standard for the assessment of sustainability in the hydrogen sector could further support the harmonization and alignment of approaches over time. By establishing an internationally agreed reference point, it could help promote consistency and comparability of sustainability-related requirements and schemes in the sector, including due diligence practices in the financial sector, certification schemes, and requirements within government funding schemes. To do so effectively, such a standard should build on existing approaches to sustainability-oriented due diligence, so that the resulting standard can foster increasing alignment of requirements, not only across countries but also across government and finance.

To foster such alignment, the standardization process should be coordinated with the proposed effort to develop sector-specific due diligence guidelines. Relevant stakeholder groups should be involved in this process, including representatives from potential importing and exporting countries as well as from finance, certification bodies, industry, civil society, and public administration. This will also be crucial for achieving broad acceptance and ownership among the relevant parties. The draft standard developed by Germany's DIN Joint Working Group on Sustainability Criteria for Hydrogen and Hydrogen Derivatives represents an appropriate starting point for such a process.

Strengthening Collaboration, Knowledge Exchange, and Capacity Building

Promoting and highlighting best practices in the implementation of sustainable hydrogen projects can also play an important role in supporting the ramp-up of the hydrogen economy. It can facilitate learning and build trust among stakeholders and the public. Moreover, it can enhance the ability of project developers to develop cost-effective approaches for complying with the due diligence required by financial institutions, thus facilitating their access to financial resources.

Activities should include the showcasing of exemplary projects and leveraging initiatives, such as the UNIDO's Global Programme for Hydrogen in Industry, the International PtX Hub, and the Green Hydrogen Organisation, to support capacity-building, knowledge sharing, and practical guidance in support of sustainable hydrogen production. In parallel, structured multi-stakeholder dialogues that bring together actors from potential exporting and importing countries can enhance cooperation, knowledge sharing, and, ultimately, increased alignment of approaches.

Cross-border coordination and knowledge exchange are particularly important for regions with projected hydrogen import needs, such as the European Union, Japan, and South Korea, while potential exporting regions can also benefit from structured cooperation. The CertHiLac initiative is a case in point. It aims to combine the regulatory requirements of potential target markets with regional challenges and priorities. Once operational, it may illustrate how a certification system can align the interests of target import regions (e.g., the EU) with those of export regions (such as Latin America and the Caribbean).

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The Research Institute for Sustainability (RIFS) conducts research with the goal of understanding, advancing, and guiding processes of societal change towards sustainable development in Germany and abroad. The Institute is embedded within the GFZ Helmholtz Centre for Geosciences and is thus part of the Helmholtz Association. Its research approach is transdisciplinary, transformative, and co-creative: RIFS cooperates with partners in science, political and administrative institutions, the business community, and civil society to understand the problems of sustainable development, identify appropriate solutions, and support their implementation in cooperation with relevant actors and affected communities. Its central research topics include the energy transition, climate change and socio-technical transformations, as well as sustainable governance and participation. A strong network of national and international partners and a Fellow Programme support the work of the Institute.

RIFS Study

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