

# SUSTAINABLE PRODUCTION AND TRADE OF POWER-TO-X

Finding the Sweet Spot



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of Research, Technology  
and Space

# ACKNOWLEDGEMENTS

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# PROJECT BACKGROUND

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

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

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

This publication is part of a publication series.



More details on each publication can be found in *chapter 7*.

All publications will be published during the course of the year 2026 and are available [here](#).



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# INTRODUCTION



The central challenge is to identify the “sweet spot” regarding robust, reliable, realistic, feasible and implementable criteria.

**Power-to-X (PtX) technologies are increasingly recognized as an essential building block of global defossilisation strategies.** By enabling the production of synthetic fuels and feedstocks from renewable electricity, PtX offers pathways to substitute fossil fuels and reduce emissions in sectors that are otherwise hard to abate, such as heavy industry, aviation and shipping. As international demand for PtX grows, trade in these products will play a crucial role in further connecting resource-rich regions with energy-importing economies.

However, the promise of PtX is not without risks. Large-scale deployment could generate significant ecological and social pressures, including water scarcity, land-use conflicts, biodiversity loss, and human rights concerns. To ensure that PtX delivers genuine economic, climate and sustainability benefits, robust sustainability frameworks are needed that cover not only greenhouse gas performance and source of electricity but also broader environmental, economic, social, and governance (EESG) dimensions.

Designing such frameworks is a balancing act. Overly rigid criteria risk stifling investment and halting deployment, while weak or fragmented standards undermine credibility and risk lock-in of unsustainable practices. The central challenge is to identify the “sweet spot” regarding robust, reliable, realistic, feasible and implementable criteria—a set of safeguards that ensures integrity while remaining practical for application across diverse geographies and governance systems.

This publication contributes to this debate by exploring (co-)benefits, barriers, and pathways for sustainable PtX production and trade. It outlines an EESG framework that aims to combine ecological integrity, economic efficiency, social equity and governance effectiveness with feasibility in implementation. **Ultimately, the goal is to provide guidance on how PtX can be scaled in a way that supports local and global climate goals, defossilisation as well as economic and sustainable development.**



# »» 2 THE CASE FOR SUSTAINABLE PtX

## 2.1 Climate Mitigation Potential

PtX technologies are increasingly recognized as critical to achieving global climate neutrality. By converting renewable electricity into hydrogen and its derivatives—such as ammonia, methanol, or synthetic fuels—PtX offers a pathway to defossilise hard-to-abate sectors that are otherwise difficult to electrify, including aviation, shipping, steelmaking, and the chemical industry (IRENA, 2022a; IEA, 2021).

Market dynamics underline the importance of PtX in global trade. Hydrogen demand is expected to rise from about 100 Mt today to more than 500 Mt by 2050 in net-zero pathways globally (IEA, 2024, p. 20; IEA, 2021, p. 99). A large share of this demand will likely be met through cross-border trade of renewable and low-carbon hydrogen and its derivatives, creating a rapidly emerging global market. Countries such as Chile, South Africa, Morocco, and Australia are positioning themselves as net exporters due to cost-efficient renewable energy resources and potentials, while for example the EU, in particular Germany, as well as Japan and South Korea are outlining strategies to secure imports as net importers (e.g. METI Japan, 2023). To support the cleanest technologies and meet its climate goals, the European Commission is in the process of establishing common standards, terminology, and certification schemes, aligned with existing climate legislation and the EU sustainable investment taxonomy. To promote PtX, the EU proposes policies and regulations to boost investor certainty, promote hydrogen adoption, develop infrastructure and logistics, adapt planning tools, and support investments (European Commission, 2020).

**In this context, reliable sustainability criteria will be decisive for competitiveness, market access and investor confidence.**



By converting renewable electricity into hydrogen and its derivatives—such as ammonia, methanol, or synthetic fuels—PtX offers a pathway to defossilise hard-to-abate sectors.

## 2.2 Risks of Unsustainable Production

Despite its promise, PtX is not inherently sustainable. If produced with insufficient safeguards, it risks undermining the very objectives it seeks to achieve. Risks can arise in environmental, economic, social or governmental terms.

Some examples are:

- › **Carbon leakage:** If PtX production draws on existing grids with high fossil shares or lacks robust additionality rules, it risks increasing net emissions instead of reducing them (Agora Energiewende, 2021a). Low-carbon but fossil-based hydrogen pathways could delay the transition and lock in infrastructure that is incompatible with net-zero goals. Reliable mechanisms should prevent carbon leakage.
- › **Water stress:** In water-scarce regions, large-scale hydrogen production could exacerbate local competition for water resources. While desalination can mitigate this risk, it adds energy demand, costs and environmental challenges such as brine disposal. Producing 1 kg of hydrogen via electrolysis requires about 9 litres of freshwater for the pure production of electrolytic hydrogen (IEA, 2019, p. 43), much more additional water is needed for cooling and other processes. Water risks can partly be mitigated by circular approaches, reusing water resources as much as possible. Also, transitioning from fossil to renewable production processes reduces water stress as they consume less water than traditional fossil fuels or fossil production routes for hydrogen (IRENA, 2023).
- › **Biodiversity loss and land-use conflicts:** Rapid expansion of projects without proper spatial planning and consideration of land and resource availability and environmental impacts can drive land-use conflicts and threaten biodiversity (WWF, 2023). These challenges highlight the importance of integrating environmental considerations and long-term land management strategies into project planning to ensure that PtX projects do not undermine ecological integrity or broader sustainability goals.
- › **Human rights concerns:** Large infrastructure projects can involve risks of human rights violations such as forced resettlement or violations of labour rights. Without safeguards such as stakeholder engagement including consultation, as well as participation, PtX may reproduce social injustices (UN General Assembly, 2025).

## 2.3 Why Safeguards are Essential

Embedding robust and sustainability safeguards is not a constraint but a strategic enabler for PtX.

Examples can be highlighted as follows:

- › **Trust and legitimacy:** Regulatory instruments ensuring genuine emissions reductions and social safeguards can increase acceptance among policymakers, investors, and civil society. An effective, and well-monitored certification system will need to be developed to ensure the safety, performance and sustainability attributes of the products and services to be traded (WTO, IRENA, 2025).

- › **Market access and competitiveness:** Governing bodies such as the EU establish strict definitions and standards for renewable fuels, e.g. EU Delegated Acts under the Renewable Energy Directive Delegated Regulation (EU) 2023/1184 and Delegated Regulation (EU) 2023/1185 (RED II and III Renewable Fuels of Non-Biological Origin, in short RFNBOs; European Commission, 2023) as well as the Carbon Border Adjustment Mechanism, in short CBAM, or the Corporate Sustainability Due Diligence Directive, in short CSDDD. Producers who meet these specifications can access high-value markets and benefit from favourable regulatory recognition. In contrast, those that fail to comply may face barriers to market entry and risk investing in technologies or products that could become commercially unviable.
- › **Long-term resilience:** By addressing water, land, and social risks early on, PtX projects will be able to address resource limitations, avoid environmental restrictions, and meet societal expectations better, leading to higher acceptance (IRENA, 2022). Strong safeguards are investments in security of supply, social license to operate, and resilience of global PtX trade.

The case for sustainable PtX is compelling. Its climate mitigation potential makes it a critical tool for global decarbonization. Yet only if PtX is produced and traded under robust and realistic sustainability standards can it contribute to a just and resilient energy transition. By finding the so-called “sweet spot” between opportunity, responsibility and implementability, PtX can become not only a climate solution but also a model for sustainable local development and global trade.



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## » 3 (CO-)BENEFITS OF ROBUST SUSTAINABILITY CRITERIA

The global expansion of PtX—particularly hydrogen and its derivatives such as e-fuels—offers great potential for decarbonising hard-to-abate sectors. Robust and implementable sustainability criteria are critical not only for ensuring environmental integrity but also for creating broad societal, economic, and geopolitical benefits, acceptance, as well as for de-risking PtX projects. This chapter outlines the primary benefits and systemic co-benefits of such criteria, making the case for their inclusion in national and international regulatory frameworks.

### 3.1 Climate and Environmental Integrity

Sustainability criteria are essential to ensure that PtX products truly contribute to climate protection and environmental integrity. When designed comprehensively, such criteria not only secure genuine greenhouse gas (GHG) reductions, but also create co-benefits for, e.g., ecosystems, water resources, and land use. Clear rules on additionality, temporal and geographic correlation of renewable electricity, and lifecycle emissions prevent indirect emissions, fossil lock-ins, and environmental degradation—ensuring that the transition to PtX strengthens rather than undermines sustainability goals.

**Robust sustainability frameworks therefore:**

#### #01

**Ensure** that PtX products are verifiably low-carbon or carbon-neutral.

#### #02

**Align** production and trade with net-zero pathways and consistent carbon accounting.

#### #03

**Promote** broader environmental co-benefits, e.g. by avoiding land-use conflicts, protecting biodiversity, and minimizing water stress.

While the EU's Delegated Acts on RFNBOs (European Commission, 2023) have put strong emphasis on aims (1) and (2), they fall short in addressing the wider environmental dimension captured by aim (3). Some initiatives already address all dimensions, but so far there is no governmental mechanisms addressing all of the dimensions mentioned above.

## 3.2 Enabling Conditions for Sustainable PtX Markets



### 3.2.1 Market Trust and Transparency

Sustainability criteria define the boundary between robust climate action and superficial mitigation claims. They help buyers, investors, and policymakers differentiate between products with verified low-carbon content and sustainability safeguards and those without. This enhances:

- › trust in PtX value chains in compliance with regulation,
- › cross-border recognition of sustainability attributes (e.g., under EU RED III or other national and international hydrogen import schemes),
- › market uptake through clear and verifiable environmental product declarations.

Governance frameworks stressing traceability, transparency, and external verification are central to ensuring confidence in PtX markets (PtX Hub, 2022).



### 3.2.2 International Trade

Sustainability criteria play a critical role in shaping global PtX trade by ensuring that products meet internationally recognized environmental and social standards.

Clear criteria enable:

- › cross-border recognition of low-carbon and sustainable attributes,
- › the export of PtX products while avoiding market fragmentation,
- › a common language for certification and verification, reducing uncertainty for importers and exporters alike.

By aligning national frameworks with regional and international systems such as EU RED III, ISO standards, or other emerging hydrogen import schemes, sustainability rules can unlock new markets, support global decarbonization efforts, and create predictable conditions for long-term investment in PtX value chains.



### 3.2.3 Investment Security

Clear, reliable and implementable criteria reduce regulatory uncertainty and signal long-term policy direction. For investors, developers, and governments, this translates to:

- › lower project risk,
- › easier access to climate finance, subsidies, and green bonds,
- › alignment with Article 6 mechanisms under the Paris Agreement.

This fosters early investment in renewable generation, electrolysis, and infrastructure that meets future sustainability and regulatory thresholds. Research shows that clear sustainability rules unlock lower-cost finance and increase investor appetite (Carbon Trust, 2023).



### 3.2.4 Good Permitting and Compliance

Sustainability criteria are also central to permitting processes and long-term compliance with regulatory requirements. Large-scale PtX projects often face complex approval procedures involving land rights, water use, environmental protection, and community engagement. Without clear rules and streamlined processes, projects risk delays, higher costs, or even cancellation due to lack of local acceptance.

According to a global market study by the World Bank and OECD, seamless permitting and compliance are critical success factors for clean hydrogen and PtX investments (World Bank, 2024, p. 45). Effective frameworks therefore need to provide transparent, predictable, and efficient permitting processes (e.g., one-stop shops and standardized procedures), strengthen administrative capacity through training and resources for permitting authorities, embed early and meaningful community engagement to secure social license to operate, ensure adherence to environmental, health, and safety (EHS) guidelines and offer mechanisms such as political risk insurance or shared permitting resources to reduce investor risk. By integrating these elements into sustainability criteria, they can:

- › improve project bankability,
- › enhance societal acceptance,
- › and reduce barriers to scaling PtX deployment.



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## 3.3 Broader Co-Benefits Across Environmental, Social, and Governance Dimensions

Well-designed sustainability criteria for PtX projects deliver value far beyond ensuring climate integrity. By embedding environmental, economic, social, and governance (EESG) safeguards, they can generate multiple co-benefits that contribute to sustainable development and long-term resilience (PtX Hub, 2022; WWF, 2023).



### 3.3.1 Environmental Co-Benefits

Sustainability rules can minimize negative externalities and actively promote environmental protection:

- › **Biodiversity conservation:** Ensuring that PtX infrastructure avoids sensitive ecosystems and integrates nature-positive design (e.g., habitat corridors, biodiversity offsets).
- › **Water stewardship:** Promoting technologies and sourcing strategies that reduce freshwater use, encourage desalination with minimal marine impact, and improve circularity in water-stressed regions, ideally building up additional water resources (e.g. through desalination) which also benefit the local communities.

- › **Circularity and innovation boost:** Establishing closed material loops for critical resources (e.g. platinum group metals, rare earths) can drive innovation in recycling technologies, create local value chains, and generate new green jobs in material recovery and processing.
- › **Enhanced ecosystem and community health:** Clean production processes for electrolysis, ammonia, and methanol can improve local air and soil quality, supporting healthier living conditions, more resilient ecosystems, and sustainable agriculture in surrounding areas, for PtX and other value chains.



### 3.3.2 Social Co-Benefits

Strong sustainability criteria also address the human dimension, ensuring that local communities are active beneficiaries of the PtX transition:

- › **Community empowerment and participation:** Early and inclusive dialogue can help local voices shape project decisions, creating social acceptance, fair outcomes, and shared prosperity instead of conflicts over land, water, or infrastructure.
- › **Employment and skills development:** Creating decent jobs adherent to ILO standards, training programs, and upskilling opportunities in renewable energy, electrolysis, and related industries.
- › **Equity and inclusion:** Maximizing social benefits by ensuring fair benefit-sharing and creating opportunities for marginalized groups, indigenous peoples, and women in both the workforce and decision-making processes. This fosters social cohesion, empowerment, and long-term community resilience.
- › **Public health and safety:** Protecting communities and employees by preventing risks associated with chemical storage, transport, or handling, while maintaining high occupational health and safety standards—ensuring a healthier, safer environment and reducing potential social and economic costs.



### 3.3.3 Governance Co-Benefits

Robust sustainability frameworks can strengthen governance structures and international cooperation:

- › **Transparency and accountability:** Promoting open data, third-party certification, and independent monitoring to reduce risks of corruption, mismanagement, or greenwashing.
- › **Regulatory alignment:** Facilitating compatibility of national PtX schemes with international frameworks (e.g., United Nations Guidelines on Business and Human Rights, ISO standards, or Paris Agreement Article 6).

› **Cross-border cooperation:** Enabling recognition of sustainability attributes across exporting and importing countries, thereby supporting global PtX trade and avoiding market fragmentation.

› **Geopolitical stability:** Reducing tensions over resource use and reinforcing trust between producing and consuming regions.

Taken together, these environmental, social, and governance co-benefits position PtX not only as a tool for defossilisation but also as a driver of sustainable local development, social equity, and international collaboration. Integrating such criteria early into regulatory frameworks can maximize synergies, build resilience, and help ensure that the global PtX economy develops in a just and sustainable manner.

**Table 1:**  
Overview of (Co-)Benefits  
with Robust PtX  
Sustainability Criteria.

The following table summarizes the (co-)benefits dimensions and examples:

DIMENSION	BENEFITS/CO-BENEFITS
<b>Climate</b>	Real GHG reductions, alignment with net-zero pathways; avoidance of indirect emissions
<b>Market</b>	Trustworthy certification; increased transparency; product differentiation; green labelling
<b>Trade</b>	Compatibility with international certification systems; facilitation of sustainable exports; cross-border recognition of sustainability attributes; avoidance of market fragmentation
<b>Investment</b>	Regulatory clarity; investment security; early mover advantage; access to finance tools
<b>Permitting and Compliance</b>	Improved project bankability; enhanced social acceptance; reduced barriers to scaling PtX
<b>Environmental</b>	Safeguards for biodiversity, land use, and water; promotion of additional renewable capacity; resource efficiency and; protection of local air and soil quality
<b>Social</b>	Job creation; community engagement; protection of human rights; just transition principles, equity and inclusion of marginalized groups; skills development and public health safeguards
<b>Governance</b>	Traceable supply chains; alignment with ESG frameworks; data-based policymaking; transparency and accountability through independent verification; strengthened international cooperation and geopolitical stability

All these factors collectively build trust among communities, investors, and policymakers and reduce conflict, foster local support, and ultimately enhance social acceptance, ensuring smoother project implementation and long-term sustainability of PtX development.

# »» 4 BARRIERS TO THE IMPLEMENTATION OF SUSTAINABILITY CRITERIA FOR POWER-TO-X (PTX)

The promise of PtX technologies as a pillar of deep defossilisation hinges on their environmental and social integrity. To safeguard this, robust sustainability criteria are essential. However, efforts to establish and implement such criteria face considerable challenges. These include political and economic resistance, technical and methodological uncertainty, institutional limitations, social tensions and trade-offs that must be openly acknowledged and managed. This chapter explores these barriers more in depth, identifying the structural and contextual hurdles that could delay or weaken the implementation of sustainability rules for PtX production and trade. Please note, that this is not a comprehensive list, but rather an insight on the variety of aspects.

## 4.1 Political and Economic Resistance

Resistance to stringent sustainability criteria often arises from fears that they may increase costs, limit flexibility, or exclude actors from emerging PtX markets.

- › **Cost sensitivity:** Demanding criteria for electricity (e.g. RFNBOs, such as narrow temporal matching and additionality), water, land or working conditions can raise production costs and slow down the scale-up of PtX projects.
- › **Delay of project implementation:** Extensive reporting duties and unclear or long timeframes of procedures can delay project implementation and therefore influence the project's business plan.
- › **Global asymmetry/trade-restrictive:** Some countries may perceive strict criteria (especially if imposed by net importing countries) as non-tariff trade barriers, hampering market access and technology transfer.

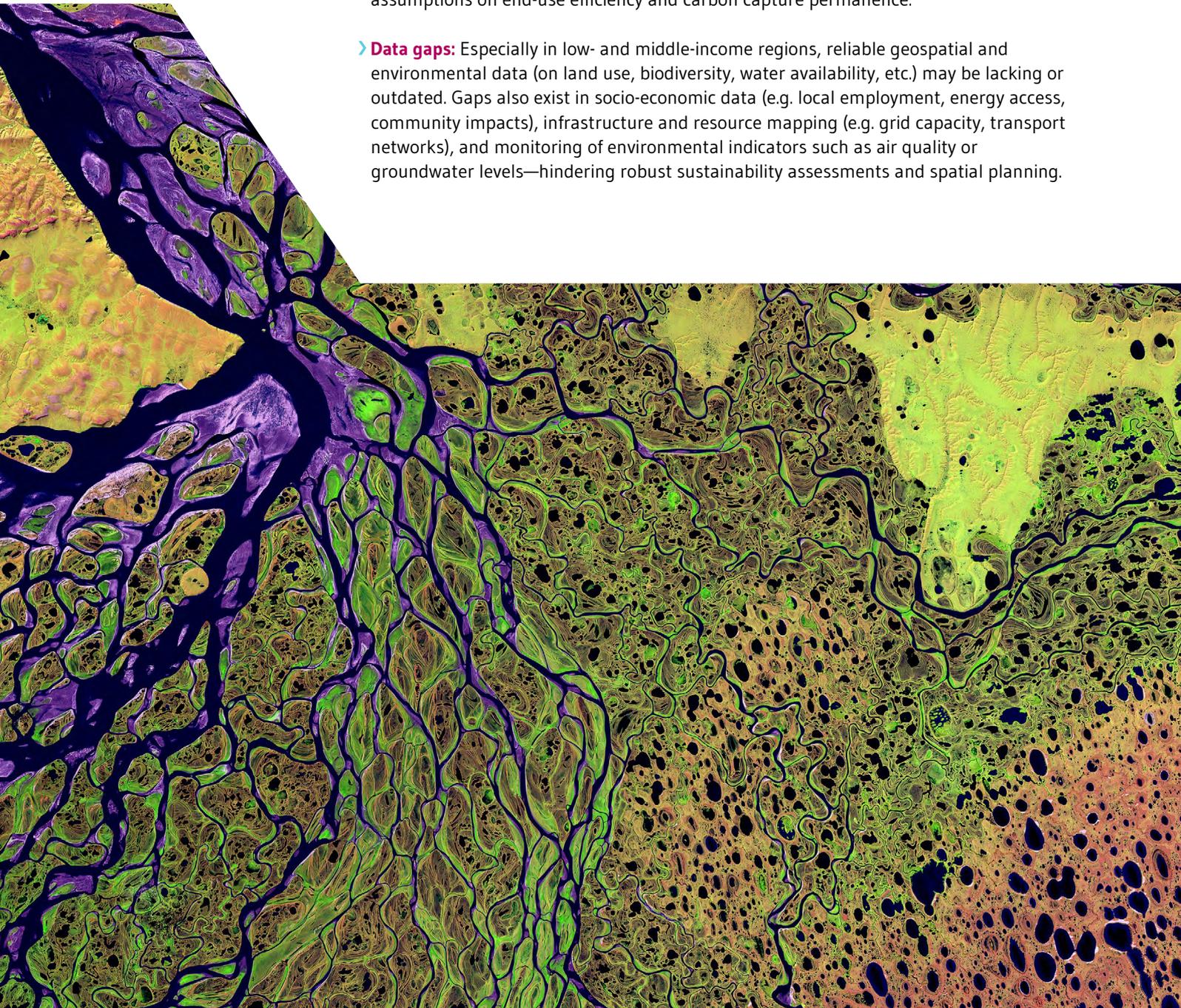


The promise of PtX technologies as a pillar of deep defossilisation hinges on their environmental and social integrity.

## 4.2 Technical and Methodological Challenges

Effective implementation of sustainability rules depends on reliable monitoring, reporting, and verification (MRV) systems and clear methodological guidance—all of which remain underdeveloped in many contexts.

- › **MRV complexity:** Verifying additionality, renewable energy use, or carbon intensity often requires real-time data tracking (e.g. smart metering, hourly matching) and digital infrastructure that some jurisdictions lack.
- › **Accounting uncertainty:** Conflicting approaches to, e.g. lifecycle emissions (e.g. treatment of transmission losses/leakages, captured CO<sub>2</sub>, or by-product allocation) can lead to inconsistent carbon intensity assessments of PtX products. Similar uncertainties can arise regarding the electricity source (e.g. temporal and geographic matching), system boundaries (e.g. inclusion of infrastructure or transport), or assumptions on end-use efficiency and carbon capture permanence.
- › **Data gaps:** Especially in low- and middle-income regions, reliable geospatial and environmental data (on land use, biodiversity, water availability, etc.) may be lacking or outdated. Gaps also exist in socio-economic data (e.g. local employment, energy access, community impacts), infrastructure and resource mapping (e.g. grid capacity, transport networks), and monitoring of environmental indicators such as air quality or groundwater levels—hindering robust sustainability assessments and spatial planning.



### 4.3 Institutional and Governance Gaps

A fragmented and under-resourced institutional landscape can impede consistent implementation and enforcement of sustainability criteria.

- › **Certification complexity:** PtX developers face a proliferation of schemes when trading internationally, partly with differing rules or technological requirements for input data. These differences between and within regimes can create shortcomings in traceability and trackability and could raise transaction costs.
- › **Lack of mutual recognition:** The absence of mutual recognition of certification schemes or sustainability definitions undermines the development of globally coherent PtX markets.
- › **Institutional capacity constraints:** Weak regulatory frameworks and limited administrative capacity may hinder the enforcement of social and environmental safeguards, increasing the risk of negative spillovers.
- › **Fragmented governance structures:** Overlapping mandates and poor coordination between ministries, agencies, and international bodies lead to inconsistent policy signals and gaps in oversight, complicating long-term planning and accountability across the PtX value chain.
- › **Fragmented local and social governance:** Diverse local power structures and decision-making processes can lack transparency and coherence, which can cause sustainability measures to reinforce existing social inequalities instead of alleviating them.
- › **Weak enforcement:** Authorities may lack the capacity to monitor and sanction violations, particularly in remote production areas, which could create sustainability risks in producing regions.

**Table 2:**  
Overview of Barriers to Robust  
PtX Sustainability Criteria

The following table gives an overview of barrier's dimensions and examples:

DIMENSION	BARRIERS
<b>Political and Economic</b>	Cost concerns, fears of competitive disadvantage, trade-restrictive
<b>Technical</b>	MRV infrastructure gaps, regional differences, missing data
<b>Methodological</b>	Inconsistent GHG accounting, unclear baseline assumptions, lack of common frameworks
<b>Institutional and Governance</b>	Certification complexity, lack of mutual recognition institutional capacity constraints, fragmented governance structures, weak enforcement

# »» 5 PTX SUSTAINABILITY DIMENSIONS: THE EESG FRAMEWORK



Building on the sustainability aspects outlined in the preceding chapters, the conceptual EESG framework developed by the International PtX Hub offers a comprehensive structure for understanding and addressing the core dimensions, opportunities and challenges of sustainable PtX development (International PtX Hub, 2022).

The framework is based on four key dimensions: Environmental, Economic, Social, and Governance (EESG); each of which captures a fundamental aspect of sustainable PtX deployment. Within each dimension, four thematic clusters of opportunities and concerns are identified, covering a total of 16 key areas where sustainability issues may arise.

The purpose of this framework is not to set fixed thresholds or standards but rather to provide a structured lens through which to analyse risks, opportunities, and trade-offs across the entire PtX value chain (from production to trade and end-use) and at multiple scales (local, national, global). It emphasises that sustainability must be addressed holistically, going beyond climate performance alone to include socio-economic development, environmental integrity, and governance capacity.

In practice, **the framework helps stakeholders:**



› **Identify** critical sustainability risks and mitigation needs at different stages of the PtX value chain.



› **Understand** how PtX projects interact with local contexts, including ecosystems, societies, and economies.



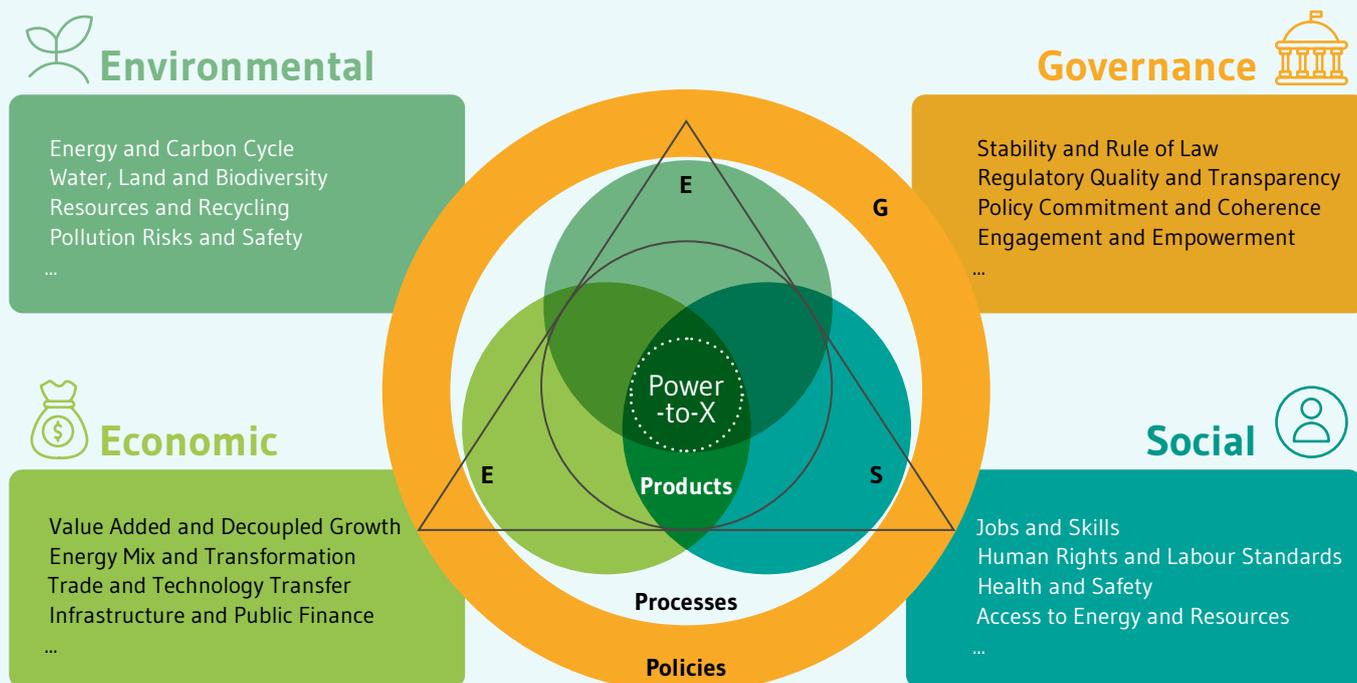
› **Design** standards, certification schemes and policies that balance environmental, economic, social, and institutional dimensions.



The purpose of this framework is to provide a structured lens through which to analyse risks, opportunities, and trade-offs across the entire PtX value chain (from production to trade and end-use) and at multiple scales (local, national, global).



**Figure 1:**  
Power-to-X Sustainability Dimensions  
EESG Framework



## 5.1 Environmental Dimension

**Assessing the environmental footprint of PtX is a fundamental element of any sustainability evaluation.** The electricity used throughout electrolysis, synthesis, and refining processes should originate from renewable sources and be additional to already planned renewable capacity expansions. Another central consideration is ensuring a closed carbon cycle in PtX production and use. This applies both to the initial power input for hydrogen generation and to the carbon utilised in synthesis processes. It must be carefully assessed whether this carbon is derived from Direct Air Capture (DAC), biogenic sources, or Carbon Capture and Use (CCU), and how potential leakages can be effectively prevented. Hydrogen and PtX production should also be closely aligned with responsible management of water, land, and biodiversity. Moreover, resource requirements, including the quantity of critical raw materials needed and their recyclability, must be thoroughly analysed. Finally, potential pollution and safety risks associated with the production, storage, transport, and use of hydrogen and PtX need to be carefully evaluated.



## 5.2 Economic Dimension

**From an economic perspective, the production, use, and trade of PtX products should primarily aim to generate added value and stimulate growth in income and employment.** However, such economic growth must be decoupled from harmful environmental and climate impacts. PtX holds significant innovative potential, and when combined with international technology transfer, it can help drive the energy transition—enabling a fundamental shift in the energy mix from fossil fuels to renewables—in a way that is mutually beneficial for all parties involved. This is particularly important in the context of international PtX trade. Assessing the economic dimension also involves analysing the infrastructure, equipment, and logistics requirements needed to support PtX deployment. Finally, public finances will be affected in multiple ways; through revenues generated from taxation and trade, as well as through expenditures on infrastructure investments, support for renewables and PtX, and assistance measures aimed at ensuring a just transition.



## 5.3 Social Dimension

**Developing PtX economies based on renewable energy has wide-ranging social and societal implications.** While it holds the promise of creating new jobs, the energy transition may also lead to job losses in fossil energy and related sectors. To ensure a just transition, capacity-building initiatives and training programmes focused on the new skills required must be implemented. Respecting human rights and the ILO Core Labour Standards (not only in first-tier operations but throughout the entire value chain) is non-negotiable. Compliance with ILO conventions prohibiting forced labour, child labour, and discrimination, as well as guaranteeing freedom of association and the right to collective bargaining, must be ensured. However, these standards are often not fully upheld in practice. Similar to environmental concerns, health and safety risks associated with PtX production, transport, and use must be closely monitored and mitigated.

Moreover, it is essential that PtX production does not negatively impact access to energy or critical resources such as water and land. On the contrary, PtX projects can potentially deliver co-benefits, for instance by integrating new renewable power installations or desalination plants, thereby creating win-win opportunities for local communities.



## 5.4 Governance Dimension

**Governance considerations are crucial for both public administration and corporate conduct.** Political stability, the rule of law, and regulatory quality are essential parameters for shaping domestic and international investment decisions. Transparency plays a vital role in preventing and combating bribery and corruption. A strong policy commitment to climate protection should be clearly reflected in a country's Nationally Determined Contribution (NDC) under the Paris Agreement. Furthermore, policy coherence—the extent to which climate objectives are integrated across economic sectors and supported by societal actors—is a key indicator of long-term sustainability.

The transition to an energy system based on renewables and PtX will only lead to a resilient and sustainable economy and society if all relevant stakeholders are not merely informed and consulted but also actively engaged and empowered throughout the process.

# »» 6 THE “SWEET SPOT” TOWARDS BALANCED CRITERIA CONSIDERING ROBUSTNESS, CREDIBILITY AND IMPLEMENTABILITY

Designing sustainability criteria always requires striking a balance between two pitfalls: criteria that are so strict that they become impossible to implement in practice, and criteria that are so weak that they fail to deliver real-world impact. In the context of energy, hydrogen, and PtX governance, this tension is particularly pronounced. On the one hand, stringent requirements ensure environmental integrity and robust climate action, hence preventing superficial mitigation claims. On the other hand, excessive rigidity can deter investment, exclude certain regions, and ultimately hinder the PtX ramp-up and hence defossilisation of hard-to-abate sectors.

The conceptual “sweet spot” therefore lies in rules that are robust enough to guarantee sustainability outcomes while still being feasible for a broad range of stakeholders to apply. The overall conceptual framework is: **Avoiding “too strict to apply” vs. “too weak to matter”.**

## 6.1 The Balancing Act

A balanced framework requires addressing four dimensions simultaneously:



### 01 Robust enough to ensure sustainability integrity:

Criteria must provide safeguards against negative environmental or social impacts and align with long-term defossilisation goals. For example, additionality in renewable hydrogen ensures that production does not cannibalize existing clean electricity capacity.



### 02 Practical enough for implementation across diverse regions and stakeholders:

Sustainability frameworks should avoid overburdening actors with administrative complexity or demanding levels of monitoring that are unrealistic in practice. A modular or phased approach as well as integration with existing frameworks can reduce barriers for emerging markets while still setting clear long-term expectations.



### 03 Flexible enough for context-specific adaptations:

Criteria should recognize that local contexts differ. For instance, water sustainability requirements may need stricter thresholds in arid regions than in water-abundant contexts. This flexibility helps avoid a “one-size-fits-all” approach that risks being either too lenient or unworkable in specific settings.



### 04 Credible enough to build trust and market confidence:

For sustainability frameworks to have real impact, they must be perceived as legitimate by policymakers, investors, and civil society alike. Transparent methodologies, consistent verification, and independent oversight are essential to ensure that sustainability claims are trustworthy and resistant to superficial claims.

## 6.2 Towards Balanced Criteria in PtX and Hydrogen

Drawing on the literature on sustainability governance and standard-setting (Cashore et al., 2004, 2006; Bernstein and Cashore, 2007; Ostrom, 2010), four overarching criteria can help assess whether a standard hits the "sweet spot":



### 01

**Effectiveness:** the extent to which criteria deliver intended sustainability outcomes (e.g., actual GHG reductions, biodiversity protection) and a just energy transition.



### 02

**Efficiency:** whether the criteria achieve outcomes with proportionate administrative and financial costs, avoiding unnecessary burden.



### 03

**Legitimacy:** the degree to which rules are accepted as fair, transparent, and accountable by affected stakeholders.



### 04

**Inclusiveness:** whether diverse stakeholders, including SMEs, civil society and marginalized groups, can realistically comply and/or benefit.



Finding this balance is not a one-off technical decision but a continuous process of negotiation, evaluation, revision and dialogue.

These dimensions reflect not only technical and environmental design but also the political and social economy of implementation. For PtX governance, the "sweet spot" will involve rules that:

- › Safeguard against carbon leakage, resource overuse and human rights violations (robustness/effectiveness),
- › are recognized and comparable internationally to avoid fragmentation but allow staged implementation (efficiency),
- › involve transparent rulemaking with public consultation (legitimacy),
- › provide capacity-building and differentiated approaches, in particular for developing countries and marginalised and effected groups (inclusiveness).

Finding this balance is not a one-off technical decision but a continuous process of negotiation, evaluation, revision and dialogue.



## »» 7 STAKEHOLDER ENGAGEMENT AS A KEY ENABLER

The development of robust yet implementable sustainability criteria for PtX production and trade cannot be achieved through technocratic design alone. Legitimacy, acceptance, and effectiveness hinge on the active engagement of a broad range of stakeholders, from governments and industry actors to local communities and civil society. Inclusive and participatory processes are essential to balancing competing interests and ensuring that sustainability safeguards are both credible and practicable.



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## 7.1 Mapping Relevant Stakeholders

Stakeholders in the PtX value chain are diverse and can pursue different, sometimes conflicting, interests. A stakeholder matrix can assist in identifying and engaging relevant parties during the development of green hydrogen strategies, also in the specific context of PtX. More detail on stakeholder mapping methodology and outcome can be found in our publication on stakeholder engagement.

The following groups are central to the governance of sustainable PtX:

- › **Project developers**, who plan and implement PtX facilities and therefore shape local environmental and social impacts. PtX customers in industry (aviation, shipping, chemicals, steel, etc), who drive demand and often set procurement standards that influence upstream sustainability.
- › **Policy makers and administration**, at national and regional levels, responsible for policy frameworks, permitting, and alignment with international climate and trade regimes.
- › **Finance institutions**, including development banks and private investors, whose funding decisions increasingly hinge on ESG performance.
- › **Certifiers and standard-setting bodies**, which translate sustainability principles into measurable and verifiable criteria.
- › **Civil society and social partners** (including NGOs, labor unions, and community organizations), who provide independent scrutiny, advocate for ambitious safeguards, and represent affected communities.
- › **Think tanks and similar organizations**, which provide evidence-based policy advice, scenario analysis, and convening capacity.
- › **Science**, which generates knowledge on ecological, social, and technological dimensions of PtX sustainability.

## 7.2 Inclusive Engagement for Legitimacy and Buy-In

**Inclusive stakeholder engagement enhances the legitimacy of sustainability frameworks by ensuring that diverse perspectives are considered in the co-creation of criteria.** Research shows that policies and certification schemes co-developed with affected groups are more likely to be accepted and effectively implemented (Gupta and Mason, 2014). For PtX, co-design processes can help reconcile tensions between ecological safeguards and economic competitiveness, or between global standards and local socio-environmental realities. Engagement also strengthens buy-in, as stakeholders who are part of the process are more likely to comply with and promote the resulting framework.

### 7.3 Challenges in Stakeholder Engagement

Despite its benefits, stakeholder engagement also faces challenges. Power imbalances are pervasive: large corporations and governments often dominate discussions, while marginalized groups may lack voice or influence. Representation is another concern, as it is difficult to ensure that participants adequately reflect the diversity of interests, especially across local, national, and global levels. Moreover, capacity gaps—such as limited technical expertise, financial resources, or institutional support—may prevent local communities or civil society actors from participating on equal terms. Addressing these challenges requires deliberate strategies, such as capacity-building and participatory programs, financial support for participation, grievance and compliance mechanisms and transparent governance structures that prevent capture by vested interests (Gupta and Mason, 2014).

### 7.4 Our Ongoing Stakeholder Engagement Process

Recognizing both the opportunities and challenges of stakeholder participation, the core of the work of WWF and the project partners International PtX Hub, DECHEMA, IZES and focus-region specific consultants, is a structured stakeholder dialogue with the aim to inform and support the development of sustainability criteria for PtX.

Our process consists of the following instruments:



**An international survey** to capture broad perspectives across countries and sectors, targeted at all different stakeholder groups. The survey collects global stakeholder perspectives on how sustainability should guide green hydrogen and PtX production, asking about project context, expectations for hydrogen's climate and economic impact, key factors for ramp-up and public acceptance, and the importance of environmental and social criteria. It also assesses views on governance mechanisms, certification initiatives, and the main challenges to creating internationally recognized sustainability standards, aiming to inform future policy and framework development.



**In-depth interviews** which are conducted across multiple world regions, with special attention to Chile and South Africa as emerging PtX exporters facing distinct ecological, social, and economic conditions. These interviews gather detailed, context-rich insights from local experts and stakeholders on opportunities, risks, and sustainability challenges in PtX development, enabling a nuanced understanding of country-specific priorities, governance realities, and on-the-ground needs for sustainable hydrogen production.



**Stakeholder workshops in key regions** Chile and South Africa, bringing together project developers, civil society and social partners, PtX off-takers, policymakers, public administrations, financial institutions, certifiers, think tanks, and researchers. These workshops create a structured space for dialogue on sustainability safeguards, enabling participants to compare perspectives, surface practical challenges, and jointly identify context-specific requirements for robust, reliable and implementable PtX sustainability frameworks.

## 7.5 Modular Publications

**Figure 2:**  
Overview of publication series.  
From Principles to Practice:  
Foundations of Sustainability  
Criteria for PtX

This modular process is designed to generate insights that are both globally relevant and sensitive to local realities. The results will be published progressively as modular publications, contributing to a more inclusive and evidence-based debate on how to identify the “sweet spot” for sustainable PtX production and trade.





This modular process is designed to generate insights that are both globally relevant and sensitive to local realities.

Our modular publication series **“From Principles to Practice: Foundations of Sustainability Criteria for PtX”** includes three sections A to C with the following seven publications:

#### **A) Sustainability Criteria: The importance of Stakeholder Engagement**

This introductory section explains why stakeholder engagement is foundational for defining credible and context-sensitive sustainability criteria in PtX. It outlines how diverse actors—ranging from local communities and civil society to project developers, regulators, and off-takers—shape the legitimacy, feasibility, and long-term acceptance of sustainability frameworks. By clarifying the roles and responsibilities of different stakeholder groups, the publication shows how inclusive engagement processes can strengthen environmental integrity, support social safeguards, and enhance project-level risk management in emerging PtX markets.

**1**

#### **SUSTAINABLE PRODUCTION AND TRADE OF PTX: FINDING THE SWEET SPOT**

This publication introduces the overarching framework for balancing environmental integrity, social equity, and economic feasibility in PtX systems. It outlines the key sustainability dimensions and the tensions between global market dynamics and local resource considerations.

**2**

#### **SOCIAL DE-RISKING: COMMUNITY PARTICIPATION, FPIC IN INDIGENOUS COMMUNITIES AND BENEFIT SHARING**

This publication explores mechanisms to ensure fair and meaningful participation in PtX projects, with particular attention to the engagement of local communities, the principle of Free, Prior and Informed Consent (FPIC) and continuous benefit sharing. It proposes criteria and best practices for engaging local communities and marginalized voices in decision-making.

#### **B) Stakeholder Voices on PtX: Insights from Around the World**

This section synthesizes insights from in-depth interviews conducted across multiple world regions, capturing how stakeholders understand opportunities and risks associated with PtX development in their specific ecological, political, and socio-economic contexts. It highlights recurring themes—such as concerns about land and water use, expectations for local value creation, and the importance of transparent governance—while also illustrating how perspectives differ between emerging exporters, established industrial economies, and frontier markets.

**3**

#### **STAKEHOLDER PERSPECTIVES ON PTX SUSTAINABILITY: INSIGHTS FROM KEY STAKEHOLDER GROUPS**

Drawing on international survey results and in-depth interviews, this study captures diverse global stakeholder views on what constitutes “sustainable” PtX and translates them into implications for PtX certification. It highlights areas of consensus and divergence among governments, PtX producers and buyers, financial institutions, academia, think tanks, and civil society and social partners, revealing regional priorities and perceived trade-offs.

4

**STAKEHOLDER PERSPECTIVES ON PTX SUSTAINABILITY: INSIGHTS FROM CHILE**

Based on deep-dive interviews and media analysis, this publication examines how sustainability is understood and debated within the Chilean PtX context. It explores national strategies, local environmental concerns, and the role of PtX as an opportunity for green industrialization.

5

**STAKEHOLDER PERSPECTIVES ON PTX SUSTAINABILITY: INSIGHTS FROM SOUTH AFRICA**

This report mirrors the Chilean study, focusing on the South African PtX debate. It investigates stakeholder perceptions, the role of PtX in South Africa's energy transition, and how sustainability priorities are shaped by domestic socio-economic and environmental challenges.

**C) Sustainability Criteria Applied: A Practical Guidance**

This section aims to link conceptual sustainability frameworks with project-level reflection in PtX project development. It focuses on how environmental, economic, social, and governance criteria can be considered and discussed within planning and decision-making processes, rather than prescribing specific implementation pathways. Drawing on applied research and stakeholder insights, the section highlights typical sustainability considerations, risks, and trade-offs that may arise in PtX projects. It illustrates how developers can use structured reflection to better understand material risks and opportunities, stakeholder expectations, and potential areas requiring further analysis or dialogue.

6

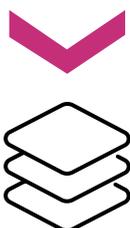
**WATER REGULATION IN PTX: INSIGHTS FROM FOCUS REGIONS**

This publication examines water as a critical environmental dimension of PtX, highlighting its central role in hydrogen production and synthetic fuel pathways. It analyses how water demand, quality, and local scarcity conditions intersect with broader sustainability objectives, showing why responsible water management is essential for PtX development. By combining regulatory review, insights from the focus regions, and expert perspectives, the section identifies key risks and formulates principles for sustainable water governance.

7

**TOWARDS SUSTAINABLE PTX PROJECTS: PRACTICAL TOOL AND GUIDANCE FOR PROJECT DEVELOPERS**

This publication provides practical guidance to support project developers in understanding and reflecting on sustainability criteria in PtX projects. It builds on the EESG framework and links directly to the new PtX Sustainability Checklist, an online tool that serves as a starting point for identifying relevant sustainability dimensions, risks, opportunities, and potential gaps at the project level.



All publications will be available over the course of the year 2026 under [here](#).

# 8 POLICY RECOMMENDATIONS AND OUTLOOK

## 8.1 Policy Recommendations

The following policy recommendations are built on the preceding analysis of barriers, co-benefits, and the need to identify a balanced “sweet spot” between robustness and implementability in PtX sustainability governance. They respond to the core insight that sustainability criteria must not only safeguard environmental and social integrity but must also be feasible for diverse producing regions and compatible with emerging international markets. Our recommendations aim to bridge global ambition and practical implementation by offering guidance that supports institutional capacity, encourages comparability across standards, protects ecosystems and communities, and enhances transparency and accountability. By situating PtX development within broader energy, climate, and development strategies, they underline the importance of coherent governance pathways that enable credible, equitable, and resilient PtX value chains.

### Governance and strategic alignment:

- 1 Integrate PtX sustainability into national strategies and bilateral partnerships:**  
Governments should embed PtX sustainability safeguards into national hydrogen and PtX strategies as well as bilateral energy partnerships. Aligning PtX development with national planning ensures coherence with energy access goals, resilience needs, and economic diversification.
- 2 Promote alignment and mutual recognition of sustainability standards:**  
International bodies and governments should work toward aligning definitions, methodologies, and verification procedures across certification schemes. Mutual recognition can reduce market fragmentation and increase transparency.
- 3 Promote adaptive and transparent governance mechanisms:**  
Establish regular review cycles for sustainability criteria, supported by transparent data sharing, independent verification, and multi-stakeholder advisory groups to ensure frameworks remain up to date and credible.

### Context-specific implementation and capacity building:

- 4 **Encourage context-sensitive, differentiated sustainability requirements:**  
Enable phased or modular compliance pathways for regions or companies with limited capacity while maintaining long-term ambition. This supports broader participation without compromising overarching sustainability goals.
- 5 **Strengthen capacity building in emerging PtX regions:**  
Provide technical assistance for MRV systems, permitting processes, water governance, administrative capacity, and community engagement. This reduces implementation barriers and supports equitable market participation.
- 6 **Link public finance and trade incentives to sustainability performance:**  
Public funding, guarantees, and trade incentives should be tied to clear sustainability benchmarks. Development banks, mid-streamer concepts or trade support mechanisms (such as H2Global or EHB auctions) should use sustainability-linked finance to reward best practices.

### Environmental and social safeguards, local value creation and resource governance:

- 7 **Implement integrated spatial planning and environmental safeguards:**  
Strategic land-use and water-use planning should guide PtX development to avoid conflicts, protect biodiversity, and ensure local environmental integrity. EIAs and SEAs should be mandatory and adapted to PtX-specific risks.
- 8 **Embed social safeguards and Just Transition measures:**  
Ensure compliance with human rights, labour standards, and Free, Prior and Informed Consent (FPIC). Promote local value creation, skills development, and high-quality jobs throughout the PtX value chain.
- 9 **Support innovation and circularity across the PtX value chain:**  
Promote R&D and market creation for technologies such as water-efficient electrolysis, sustainable desalination, recycling of critical materials, and circular design principles for PtX infrastructure.



Our recommendations aim to bridge global ambition and practical implementation by offering guidance that supports institutional capacity, encourages comparability across standards, protects ecosystems and communities, and enhances transparency and accountability.

## 8.2 Outlook

Ensuring robust EESG safeguards is crucial for promoting truly sustainable PtX trade. Striking the right balance between the rigor of these safeguards and their practical implementability is essential to make sustainability standards effective in real-world contexts. Achieving and maintaining this “sweet spot” relies heavily on continuous engagement with stakeholders across the value chain, whose insights and collaboration are key to designing safeguards. By combining strong standards with inclusive dialogue, sustainable PtX trade can advance in a way that is economically viable, environmentally responsible and socially acceptable.

To advance sustainable PtX development, existing certification and sustainability schemes should be identified, mutually recognized, and—where feasible—harmonized. International standards should be applied wherever they are effective and efficient. Mutual recognition can reduce market fragmentation, lower complexity for producers, and build trust among investors and customers. Key actions include mapping and comparing existing certification systems, aligning methodologies, and developing recognition mechanisms to avoid duplicative audits and verification. Pilot projects in diverse regions should test EESG criteria under real-world conditions, generate lessons learned, and refine guidelines and verification procedures. Sustainability requirements should be embedded into trade and investment agreements, supported by capacity building and practical tools for project developers and authorities.

In the longer run, globally recognized, transparent, and enforceable governance frameworks should be established—through international agreements, an independent certification and verification body (e.g., ISO standard), and integration with broader energy and climate policies. Continuous multi-stakeholder dialogue is essential to review criteria, share data transparently, and adapt to new insights. Adaptive governance will be key to ensuring that PtX value chains are sustainable, credible, and resilient.



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## APPENDIX: OVERVIEW OF CERTIFICATION AND STANDARDIZATION INITIATIVES AND ANALYSIS



The following table contains a list of the existing certification and standardization initiatives which are currently being developed or already active. The list is composed of own research and other secondary sources mentioned below. It should be extensive and accurate, but might not cover all initiatives worldwide, and maybe not always cover the latest status, as many are still under development, rapidly evolving and accurate resources are not always publicly available. If you miss relevant data or find errors, please make the authors aware.

The table gives information on the type of initiative (government/regulatory; government/regional; government/fiscal incentive; public private mechanism; private/voluntary), the name of the initiative, a short description, the current status and if it includes the parameter electricity source, GHG emissions, carbon source and additional ESG criteria.



A more extensive analysis in the form of a database of schemes and detailed scheme contents, compiled by IPHE, can be found [here](#).

Type	Name	Short Description	Status	GHG Emissions	Electricity Source	Carbon Source	Additional ESG
Government/regulatory	<b>EU RFNBO (RED II/RED III)</b>	EU framework defining renewable fuels of non-biological origin (RFNBOs), incl. hydrogen—rules for additionality, traceability, certification.	In force, certification via recognized schemes, see below	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	/
Government/regulatory	<b>Australia Government Standard</b>	Regulatory framework in Australia for hydrogen project eligibility and compliance.	In development/adoption	Yes (thresholds not yet formalised)	Yes	Yes	Some (export governance, sustainability)
Government/regulatory	<b>UK Renewable Transport Fuel Obligation (RTFO)</b>	UK regulation requiring sustainability and reporting for fuels, applicable to hydrogen in transport.	In force, hydrogen inclusion evolving	Yes (~55–65% lifecycle GHG saving required vs fossil fuels)	Yes	Yes	Yes (land use, biodiversity, water, sustainability checks)
Government/regulatory	<b>UK Low Carbon Hydrogen Certification Scheme</b>	UK framework defining how hydrogen qualifies as low-carbon for policy and regulatory support.	In development/pilot phase	Yes (≤20 g CO <sub>2</sub> e/MJ <sub>lHV</sub> )	Yes	Yes	Some (reporting, fugitive risks)
Government/regulatory	<b>Korea Clean Hydrogen Certification Scheme</b>	National Korean scheme certifying clean hydrogen for incentives and compliance.	In force/being implemented	Yes (≤4 kg CO <sub>2</sub> e/kg H <sub>2</sub> )	Yes	(Yes)	Some (documentation, verification)
Government/regulatory	<b>Japan Low-carbon Hydrogen Certification</b>	National certification defining measurement and eligibility for low-carbon hydrogen in Japan.	Active	Yes (direct/process focus)	Yes	Yes	Some (regional focus)
Government/regional	<b>Japan—Prefecture Aichi</b>	Local/regional pilot scheme for hydrogen sustainability certification in Aichi Prefecture, Japan.	Active regional pilot	Yes (direct/process focus)	Yes	Yes	Some (regional focus)
Government/regulatory	<b>US Government Standard(s) (bundle)</b>	Federal rules and incentive frameworks defining clean hydrogen eligibility (includes production tax credits and guidance).	Active, evolving (e.g. 45V in implementation), in discussion	Yes (≤4 kg CO <sub>2</sub> e/kg H <sub>2</sub> target)	Yes	(Yes)	Some (procedural, verification)
Government/regional	<b>US (California) Low Carbon Fuel Standard (LCFS)</b>	California regulation assigning carbon intensity to fuels, low-carbon hydrogen can generate LCFS credits.	Operational, used for hydrogen credits	Yes (carbon intensity based, lifecycle)	Yes	Yes	Some (equity, reporting, crediting)
Government/fiscal incentive	<b>US Clean Hydrogen Production Tax Credit (45V)</b>	Federal tax credit for hydrogen meeting lifecycle emissions thresholds.	Final rules issued in 2025, eligibility window politically contested	Yes (carbon intensity based, lifecycle)	Yes	Yes	Some (verification, audit, 3-pillar rules)
Government/fiscal incentive	<b>US Colorado clean hydrogen tax credit</b>	State-level tax incentive for clean hydrogen projects in Colorado.	Active	Yes (state thresholds, e.g., 1.5 kg CO <sub>2</sub> e/kg H <sub>2</sub> )	Yes	Yes	Some (community and cumulative impact reporting)
Government/fiscal incentive	<b>Canada Clean Hydrogen Investment Tax Credit (ITC)</b>	Federal support scheme that grants tax credits based on the life-cycle carbon intensity in Canada.	Active	Yes (carbon intensity thresholds)	Yes	Yes	Some (labour requirements, verification)
Public-private mechanism	<b>Germany H2Global</b>	Mechanism to de-risk and support international hydrogen trade via auctions and contracts.	Active, first and second funding window launched	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	Yes (ESG criteria)
Public-private mechanism	<b>Danish PtX Tender</b>	Support scheme for the development of Denmark's domestic hydrogen production.	Auctions in 2023	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	Includes EIA
Public-private mechanism	<b>European Hydrogen Bank (EHB) Pilot Auction</b>	Market-based initiative to support and incentivize the production of renewable hydrogen in Europe through competitive bidding.	Active, several auction rounds, here: 2025 call	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	(Yes)	Proposal to include DNSH (do no significant harm) strategy (inc. protection of water)
Public-private mechanism	<b>UK First Hydrogen Allocation Round (HAR1)</b>	Mechanism to support the development of the United Kingdom's domestic hydrogen production.	Auctions in 2022 and 2023, closed/contracts being signed	Yes, LCHS GHG threshold applies	Yes	N/A	Some (deliverability, cost, economic benefits, environmental impact and market development)

TYPE	NAME	SHORT DESCRIPTION	STATUS	GHG EMISSIONS	ELECTRICITY SOURCE	CARBON SOURCE	ADDITIONAL ESG
Private/voluntary	<b>CertifHy (EU RFNBO)</b>	A voluntary European certification initiative for renewable/low-carbon hydrogen (guarantees of origin, traceability, GHG accounting).	Officially recognized by European Commission for RFNBO	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	/
Private/voluntary	<b>CertifHy Non-Governmental Certificate (NGC)</b>	A 'non-governmental certification' (book and claim), Voluntary GO Certification by CertifHy, two paths: 'Green Hydrogen' and 'Low Carbon Hydrogen'	Fully operational; used in jurisdictions without national GO system	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	(Yes)	/
Private/voluntary	<b>REDCert</b>	European certification scheme adapted from biofuels, extended to hydrogen/fuels for traceability, mass balance, sustainability.	Officially recognized by European Commission for RFNBO	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	/
Private/voluntary	<b>ISCC EU</b>	Certification scheme that ensures that biofuels, RFNBOs, and recycled carbon fuels meet EU criteria on GHG savings, sustainability, and traceability across the entire supply chain.	Officially recognized by European Commission for RFNBO	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	/
Private/voluntary	<b>ISCC PLUS</b>	Multi-commodity sustainability certification system (incl. hydrogen) with chain-of-custody, GHG reporting and traceability.	For non-fuel markets (chemicals, plastics, food, etc.)	N/A, can be added	Yes	Yes	/
Private/voluntary	<b>DIN 35809</b>	Sustainability criteria for hydrogen and hydrogen derivatives, meta standard as a result from a standardization gap analysis "Standardization Roadmap for Hydrogen"	In development	Yes, no threshold given	Yes	Yes	Yes (ESG criteria)
Private/voluntary	<b>TÜV Rheinland Standard H2.21</b>	TÜV Rheinland's standard for certifying hydrogen pathways for 'Renewable and Low-Carbon Hydrogen Fuels'.	Pilot/selected projects	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	Yes	/
Private/voluntary	<b>TÜV Süd Standard CMS 70</b>	TÜV Süd's standard for hydrogen certification (conformity, auditing, traceability).	Active in certification discussions	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	N/A	/
Private/voluntary	<b>TÜV Süd Standard CMS 70 for Green Hydrogen+</b>	TÜV Süd's slightly elevated standard for hydrogen certification.	Active globally	70% savings (≤28,2 g CO <sub>2</sub> e/MJ)	Yes	N/A	/
Private/voluntary	<b>Zero Carbon Certification Scheme (Australia)</b>	Voluntary Australian certification for hydrogen/energy carriers classified as zero carbon under defined criteria.	Pilot/emerging	Zero-carbon requirement	Yes	Yes	/
Private/voluntary	<b>Green Hydrogen Standard</b>	Voluntary standard defining criteria for green hydrogen (renewables sourcing, additionality, lifecycle accounting).	Emerging/partial adoption	Strict renewable-based CI	Yes	Yes	Yes (ESG criteria)
Private/voluntary	<b>RSB Standard for Advanced Fuels</b>	Sets sustainability, social, and greenhouse gas criteria for advanced biofuels and synthetic fuels; at the moment applicable only outside the EU.	Active, Version 2.6 (2023)	CI thresholds	Yes	Yes	Yes (ESG criteria)
Private/voluntary	<b>Climate Bonds Initiative</b>	Framework for certifying hydrogen production and delivery projects under the Climate Bonds Standard; incl. broader sustainability standards.	Active	Renewable/clean/low-carbon thresholds	Yes	LCA	Yes (ESG criteria)
Private/voluntary	<b>China Hydrogen Alliance Standard</b>	First formal standard to quantify hydrogen's carbon emissions incl. LCA, for renewable, clean and low-carbon hydrogen.	Active (since 2020)	≤14.5 (low-carbon)/ ≤4.9 kg CO <sub>2</sub> e/kg (clean/renewable)	Yes	Yes	/
Private/voluntary	<b>CertHILAC</b>	Harmonized Hydrogen Certification System for Latin America and the Caribbean, two certification categories tailored to local and EU market requirements, focusing on clean and low-carbon hydrogen, incl. broader sustainability criteria.	In development	Clean/low-carbon thresholds	Yes	Yes	Yes (not yet published)

This publication does not analyse the initiatives in more detail, since this has been done in the past by other actors, but instead links to relevant publications comparing sustainability standards, initiatives, and broader regulatory mechanisms.

Relevant publications can be found here:

PtX Lab Lausitz (2025): Sustainability Criteria for Green Fuels and Basic Materials from Renewable Energy: A Comprehensive Approach for a Rapid and Secure Market Ramp-Up: <https://ptxlablausitz.de/en/publications/sustainability-criteria-for-green-fuels-and-basic-materials-from-renewable-energy/>

RIFS (2025): Governance for a Sustainable Hydrogen Economy: Lessons from Bioenergy in the EU: [https://publications.rifs-potsdam.de/rest/items/item\\_6004467\\_2/component/file\\_6004565/content](https://publications.rifs-potsdam.de/rest/items/item_6004467_2/component/file_6004565/content)

Fraunhofer IEE/IMWS/CSP (2025): Sustainability regulations for PtX projects: Scope and impact analysis: [Sustainability regulations for PtX projects: Scope and impact analysis](#)

FICHTNER (2024): Overview of EU Certification Schemes (CertifHy, TÜV Rheinland Standard H2.21, ISCC Plus, TÜV Süd Standard CMS 70): [https://www.fichtner.de/userfiles/fileadmin-group/Dateien/Publikationen/240331H2Uppp\\_Green\\_Hydrogen\\_Certification\\_Schemes\\_extended\\_report\\_V2.pdf](https://www.fichtner.de/userfiles/fileadmin-group/Dateien/Publikationen/240331H2Uppp_Green_Hydrogen_Certification_Schemes_extended_report_V2.pdf)

IPHE (2024): Comparison of Hydrogen Certification Schemes—Methodology and Results: [https://www.iphe.net/\\_files/ugd/45185a\\_e097bcac08984a3a87201790b30b145c.pdf](https://www.iphe.net/_files/ugd/45185a_e097bcac08984a3a87201790b30b145c.pdf)

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H2Global Foundation (2024): Auction Design Report: Keep it simple: Aligning auction objectives for success: <https://h2-global.org/library/keep-it-simple-aligning-auction-objectives-for-success>

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