International Renewable Energy Agency

Green hydrogen derivatives
Trends in regulation, standardisation and certification

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IRENA Innovation and Technology Centre

IRENA serves 170 member countries

- We were established in 2011
- Our headquarters are in Masdar City, Abu Dhabi, UAE, and the IRENA Innovation and Technology Centre is located in Bonn, Germany
- We support member countries to address the opportunities and challenges of the energy transition

Mandate

To promote the widespread adoption and sustainable use of **all forms of renewable energy** worldwide

Bioenergy | Geothermal Energy | Hydropower | Ocean Energy | Solar Energy | Wind Energy

Setting the scene: the role for renewable hydrogen in the global energy transition

On the role of hydrogen in IRENA's 1.5°C Scenario

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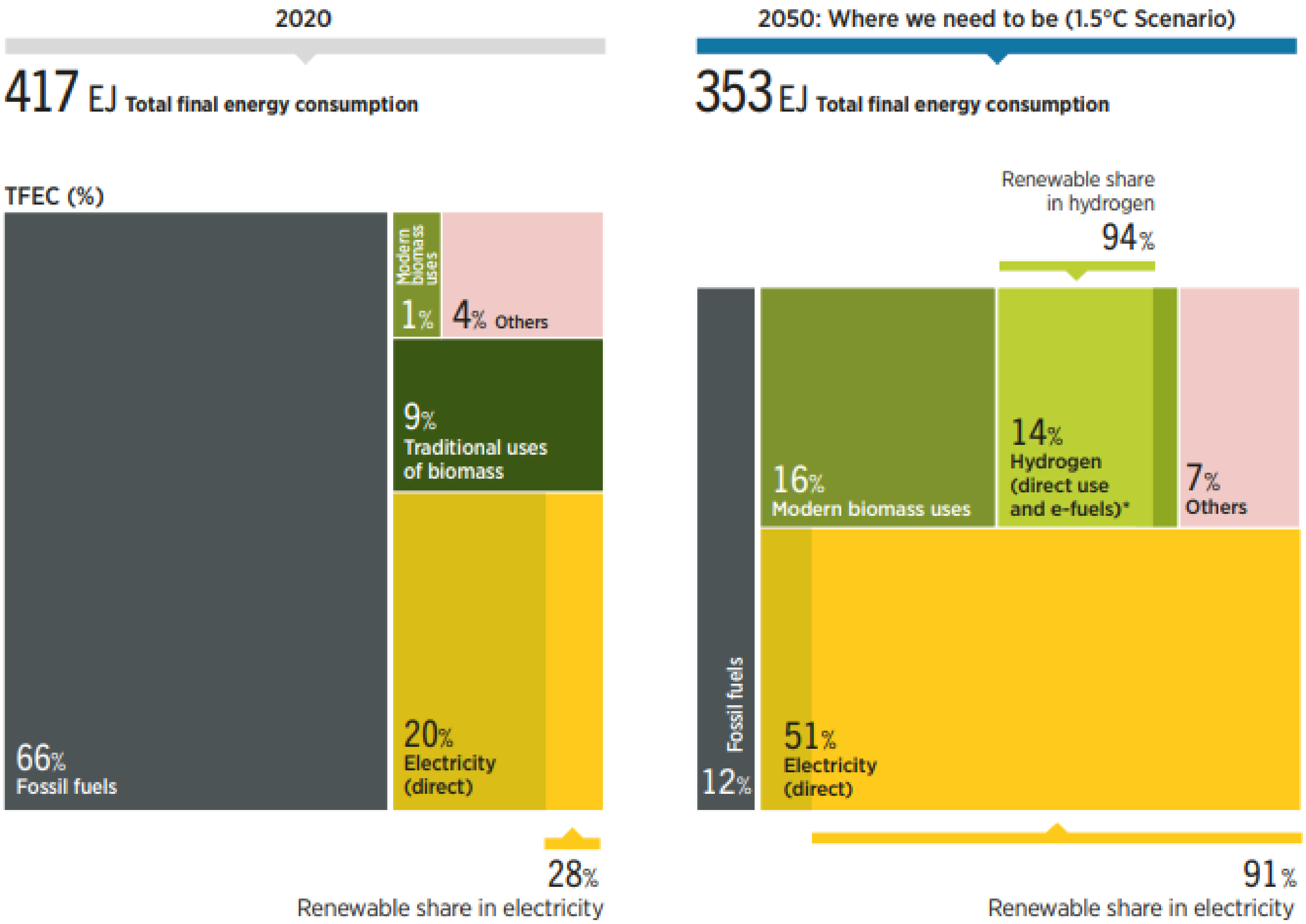
Breakdown of total final energy consumption by energy carrier in 2020 and 2050 under IRENA's 1.5°C Scenario:

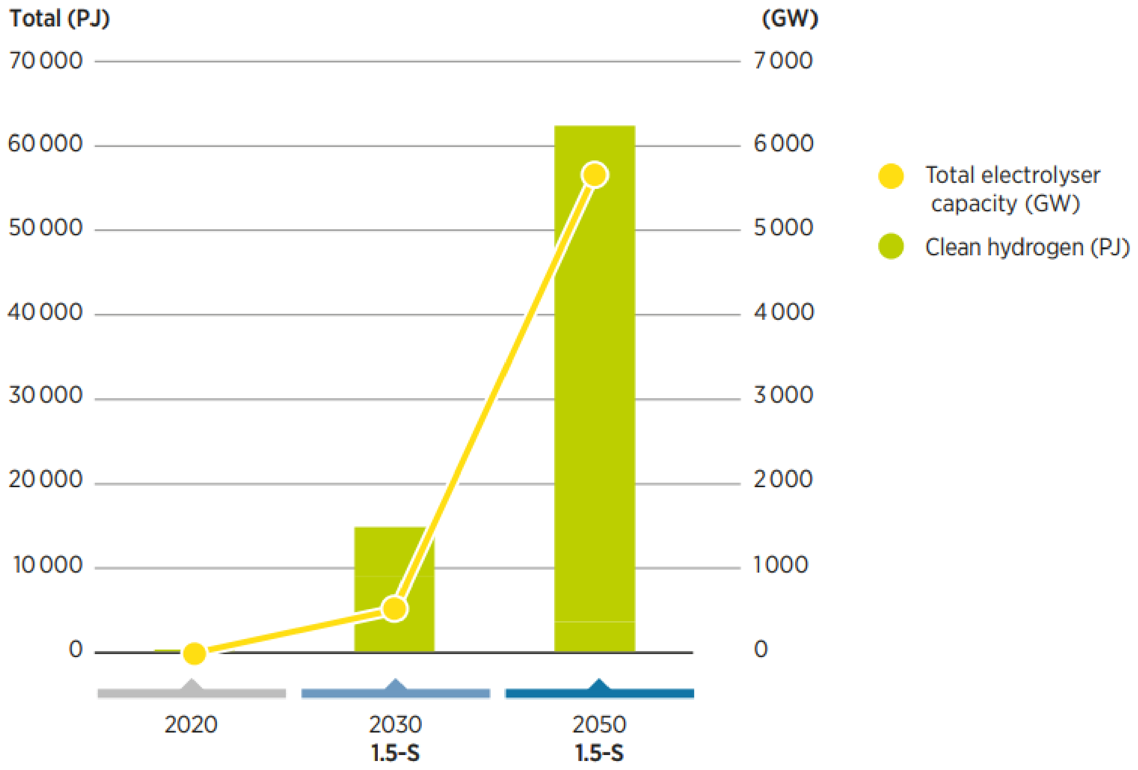


- By 2050, **electricity becomes the main energy carrier**, addressing more than half of the global final energy demand.
- Hydrogen and hydrogen derivatives make up around **14% of total final energy consumption by 2050**.
- **94% of hydrogen production** should **come from renewables** by 2050.

Source: IRENA, 2023. World Energy Transitions Outlook 2023: 1.5°C Pathway, Volume 1

Scaling hydrogen production will be a major challenge

Global clean hydrogen supply in 2020, 2030 and 2050 in IRENA's 1.5°C Scenario.



Notes: 1.5-S = 1.5°C Scenario; GW = gigawatt; PJ = petajoule.

- Most of **today's hydrogen production is fossil-derived** (mostly natural gas, but also coal)
- Most global hydrogen **production in 2050 should come from renewables**
- The electricity requirement for **green hydrogen in 2050 is comparable to today's global electricity consumption.**
- This entails an expansion in electrolysis capacity from **~ 1 GW to >5700 GW** by 2050.

Source: IRENA, 2023. World Energy Transitions Outlook 2023: 1.5°C Pathway, Volume 1

Differences in localised levelised cost of hydrogen in 2050 may drive competitive advantages

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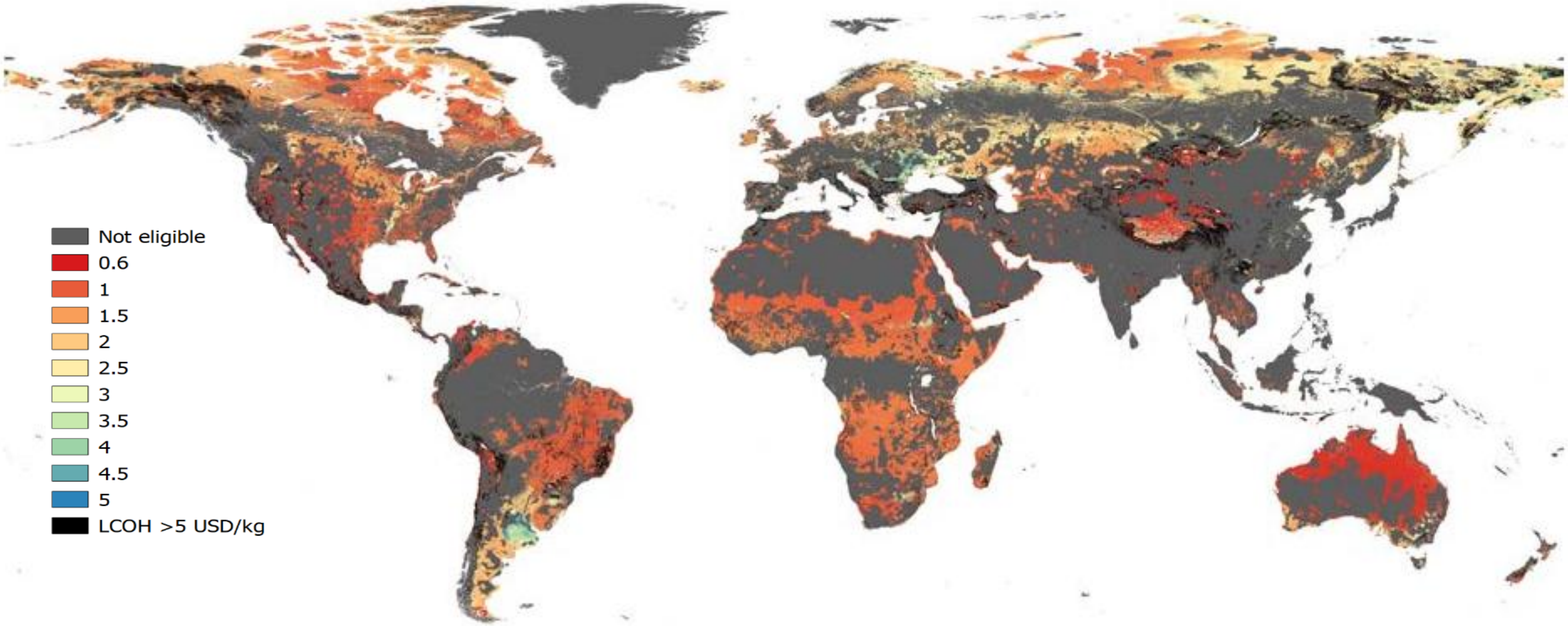
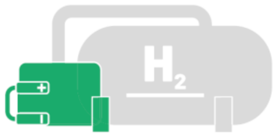
Global levelised cost of hydrogen (LCOH) in 2050



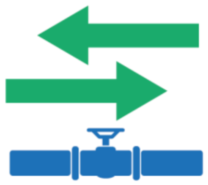
Note: Assumptions for capital expenditure are as follows: solar photovoltaic (PV): USD 270-690/kW in 2030 and USD 225-455/kW in 2050; onshore wind: USD 790-1435/kW in 2030 and USD 700-1 070/kW in 2050; offshore wind: USD 1 730-2 700/kW in 2030 and USD 1 275-1 745/kW in 2050; electrolyser: USD 380/kW in 2030 and USD 130/kW in 2050. Weighted average cost of capital: Per 2020 values without technology risks across regions. Land availability considers several exclusion zones (protected areas, forests, permanent wetlands, croplands, urban areas, slope of 5% [PV] and 20% [onshore wind], population density, and water availability). Source: IRENA, 2022. Global hydrogen trade to meet the 1.5C goal. Part I: Trade outlook for 2050 and way forward

About a quarter of the global hydrogen demand could be internationally traded

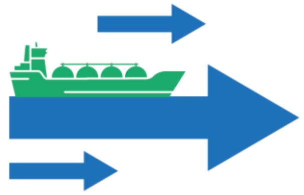
Global hydrogen trade flows under optimistic technology assumptions in 2050



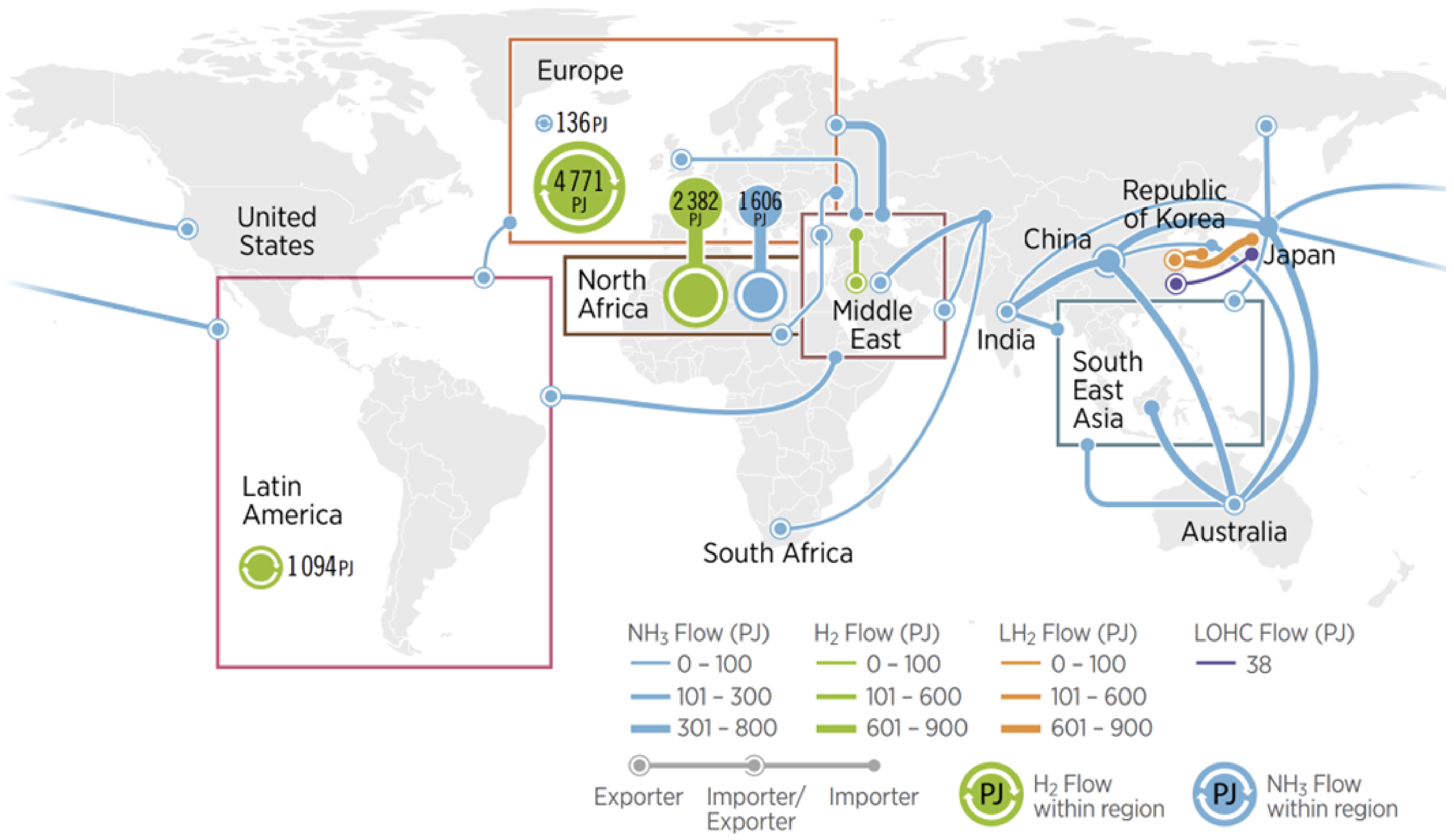
By 2050, international trade could satisfy about ¼ of the total global hydrogen demand in IRENA's 1.5°C scenario.



55% of this hydrogen would be traded via pipelines.



45% of this hydrogen would be shipped, predominantly as ammonia.



Source: IRENA, 2022. Global hydrogen trade to meet the 1.5C goal. Part I: Trade outlook for 2050 and way forward.

Trends in regulations, standards and certifications

Sustainability considerations – life cycle of green hydrogen

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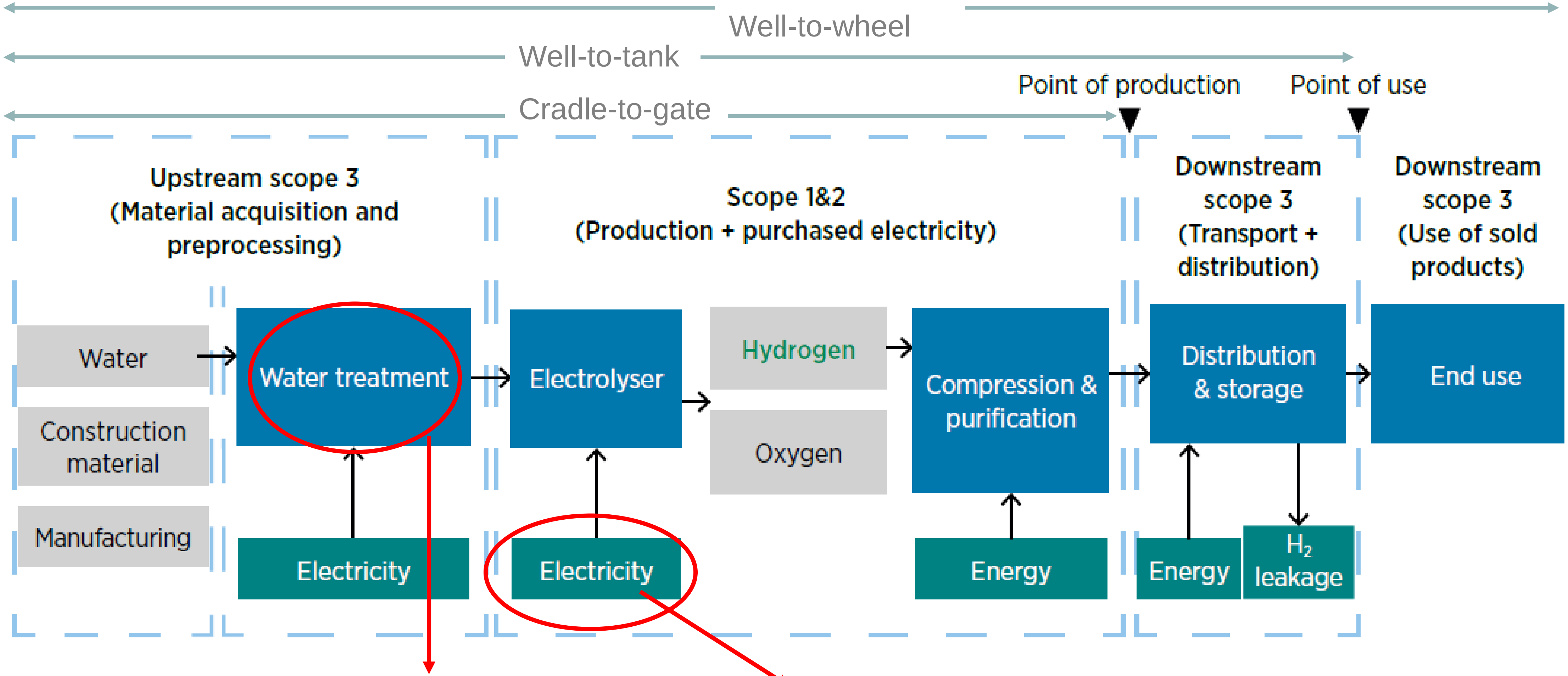


Water needs to be sourced sustainably:

- Desalination is an option for coastal regions
- Shared resources can lead to co-benefits
- Water also needed for cooling (high for grey H2)

Renewable electricity needs to meet sustainability requirements:

- Additionality
- Time matching
- Geographic correlation

Sustainability considerations for green hydroen - Electricity

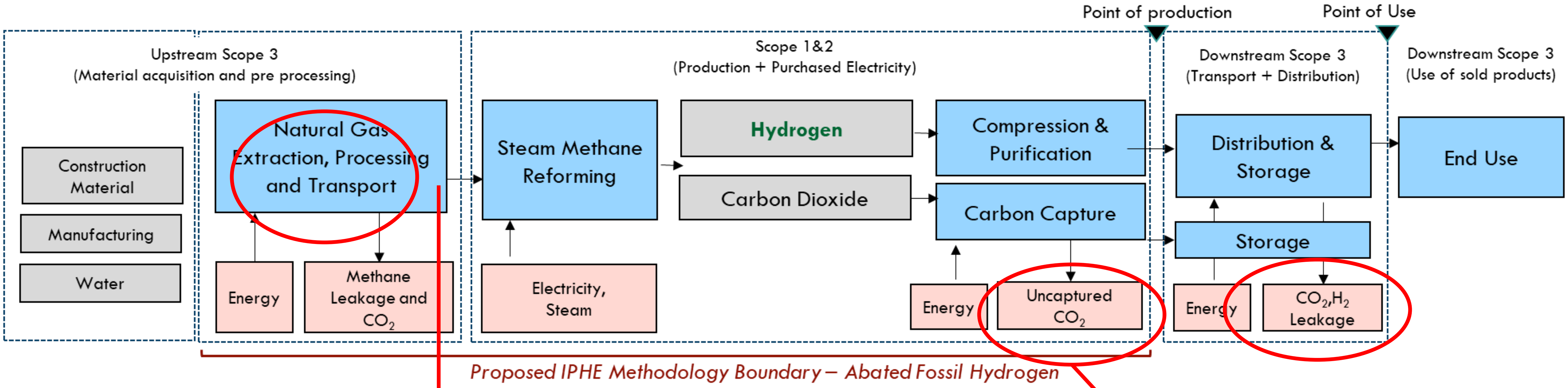
Three principles to ensure that electricity used in electrolysis is sustainable:

- **Additionality:** Ensure that electrolysis does not consume renewable energy that had another use (otherwise, this renewable generation now diverted to H2 would have to be substituted at the margin, probably by fossil energy)

- **Time-matching** Ensure that renewable electricity is generated **at the same time** as it is used by electrolysis. E.g. in the EU, the H2 producer is required to deliver renewable energy certificates (or PPAs) corresponding to the monthly consumption. The requirement runs until the end of 2029.

- **Deliverability** A **physical connection** is required between the renewable generator and the electrolyser, i.e. it must be injected into the same electricity system. E.g. To participate in the European Hydrogen bank auctions, the renewable generation is required to be no more than 500km from the electrolyser.

Sustainability considerations – life cycle of Blue Hydrogen



Scope:

- Include transport of natural gas?
- Include transport from point of production to point of use?

Sustainability risks:

- Methane and CO_2 leakage
- CCS capture efficiency (ranges from 70-90%)

(Regulation), standardisation, and certification

Definitions and key elements for standards and certification schemes

	Standard	Certifications
Explanation	A formal method or formal guidance that stipulates how to determine the characteristics of a system and may also define the characteristics of a system	Certification is the formal process which an accredited third-part body ensures a system adheres to a specified standard
Key elements	Procedures for evaluating characteristics and conformity, terms and definitions, Criteria for compliance	Assessment Process, third-party involvement, conformity to standards, validity period

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

Differences among standards and certification schemes

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1. Sustainability criteria covered (Additionality of renewable power source, Time matching, Geographic correlation)
2. Methodologies for calculating GHG emissions
   - Scope of the supply chain covered
     - whether to include upstream emissions from transporting primary materials
     - whether to include upstream methane emissions for hydrogen produced from methane/ natural gas (ISO/TS 19870:2023 includes them)
     - whether to include emissions from transporting the product/fuel to the point of use (i.e. most jurisdictions - require Well-to-Gate, whereas the EU requires Well-to-Point of Use. The EU is in line with ISO/TS 19870:2023
     - whether to include emissions from leaks (also linked to the primary/secondary point below).
     - whether to include 'CAPEX emissions' (ISO/TS 19870:2023 includes this)
   - Whether calculations require the use of primary vs secondary sources of data (default values)
3. Level of assurance (certification scheme)
   - Tracking methodology (mass balance or book and claim / guarantee of origin)
   - Accreditation and other requirements of the certification bodies / auditors

We see a more mature regulations landscape for hydrogen than for the derivative sectors

Overview of definitions of green and low-emission hydrogen and its derivatives in selected markets

<table>
<tr><th></th><th>Hydrogen</th><th>Ammonia</th><th>Methanol</th><th>Iron and steel</th></tr>
<tr><td>Canada</td><td>Investment Tax Credit: Emission intensities <0.75, 0.75-2, 2-4 $kgCO_2eq/kgH_2$</td><td>Investment Tax Credit: Emission intensities <4 $kgCO_2eq/kgH_2$</td><td></td><td></td></tr>
<tr><td>European Union</td><td colspan="3">RED: <3.4 $kgCO_2eq/kgH_2$. Includes criteria on temporal correlation, geographical correlation and additionality; additional criteria apply to the sourcing of carbon for methanol.
EU Taxonomy (for hydrogen): <3 $kgCO_2eq/kgH_2$</td><td>EU Taxonomy: <1 331 $kgCO_2eq$ per kg of hot metal[10]</td></tr>
<tr><td>India</td><td colspan="3">Clean Hydrogen Standard: From renewable energy with emission intensity <2 $kgCO_2eq/kgH_2$</td><td></td></tr>
<tr><td>Japan</td><td colspan="2">Basic Hydrogen Strategy: Production with emission intensity <3.4 $kgCO_2eq/kgH_2$</td><td></td><td></td></tr>
<tr><td>Republic of Korea</td><td>Clean Hydrogen Certification Mechanism: Production with emission intensity <4 $kgCO_2eq/kgH_2$</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">United Kingdom</td><td>UK Low Carbon Hydrogen Standard: Production with emission intensity <2.4 $kgCO_2eq/kgH_2$</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Renewable Transport Fuel Obligation:[11] Production with emission intensity <4 $kgCO_2eq/kgH_2$</td><td></td><td></td></tr>
<tr><td>United States</td><td>Production Tax Credit: Emission intensities <0.45, 0.45-1.5, 1.5-2.5, 2.5-4 $kgCO_2eq/kgH_2$</td><td></td><td></td><td></td></tr>
<tr><td>California (United States)</td><td>Low Carbon Fuel Standard: Default values of emission limits ranging from 1.3 to 18.1 $kgCO_2eq/kgH_2$</td><td></td><td></td><td></td></tr>
</table>

10 *Not specifically tied to hydrogen-based production routes.*

11 *The UK Renewable Transport Fuel Obligation is applicable to ammonia and methanol for maritime and aviation fuels.*

Sources: IRENA and RMI (2023), Creating a global hydrogen market: Certification to enable trade; IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

The landscape for hydrogen standards and certifications has grown since IRENA's previous stocktake

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Landscape of standards and certification initiatives for hydrogen

Standards and Methodologies

ISO 14067	ISO 14040	ISO 14044
ISO 14064-1	ISO TS/19870	IPHE Methodology
GHG Protocol	ISCC EU Doc. 205	RSB Standard Methodology 010
TÜV SÜD Standard CMS 70 Green Hydrogen	TÜV Rheinland Standard H2.21	UK Low Carbon Hydrogen Standard
China Hydrogen Alliance Standard	Carbon Neutral H_2 Standard	GH2 Green Hydrogen Standard

Certifications

CertifHy (Europe)	UK Renewable Transport Fuel Obligation	VertiCer (Netherlands)
Guarantee of Origin Scheme (Australia)	Zero Carbon Certification Scheme (Australia)	Aichi Prefecture Certification (Japan)
Bureau Veritas Renewable Hydrogen Certification	RSB Global Fuels Certification	ISCC Plus
CertiHILAC (Latin America)	GH2 Green Hydrogen Standard	Climate Bonds Initiative

Notes: ISO = International Organization for Standardization; IPHE = International Partnership for Hydrogen and Fuel Cells in the Economy; ISCC = International Sustainability & Certification; RSB = Roundtable on Sustainable Biomaterials; TÜV = the Technischer Überwachungsverein (Technical Inspection Association); UK = United Kingdom; GH2 = the Green Hydrogen Organization. DNV = Det Norske Veritas; GH2 = Green Hydrogen Organization; IPHE = the International Partnership for Hydrogen and Fuel Cells in the Economy; ISO = International Organization for Standardization; GHG = greenhouse gas emissions; SBTi = the Science Based Targets Initiative; TfS PACT = Together for Sustainability Partnership for Carbon Transparency; ISCC = International Sustainability & Certification; AEA = the Ammonia Energy Association; RSB = the Roundtable on Sustainable Biomaterials; TÜV = the Technischer Überwachungsverein or Technical Inspection Association.

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

There is a diverse array of standards and certification schemes for hydrogen derivates also

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Landscape of standards and certification initiatives for Ammonia

Standards and Methodologies

- DNV Ammonia
- GH2 Green Ammonia Protocol
- IPHE Ammonia
- ISO 14067
- ISO 9000
- ISO 14044
- ISO 14064-3
- GHG Protocol
- SBTi Chemicals*
- TfS PACT Chemicals
- ISO 14040

Certifications

- ISCC Plus Chemicals
- Bureau Veritas Ammonia
- AEA Ammonia Certification
- RSB Global Fuel Certification
- ISCC EU
- Climate Bonds Chemicals
- TUV Rhineland Low carbon fuels

Landscape of standards and certification initiatives for Iron and Steel

Standards and Accounting Methodologies

- worldsteel CO_2 methodology
- ISO 14040
- ISO 20915
- EN 19694
- worldsteel LCI methodology
- GHG Protocol
- ISO 14404
- ISO 14060
- SBTi for Steel
- Steel Zero
- CEM IDDI
- RMI Steel Sector Guidance
- First Movers Coalition
- Sustainable STEEL Principles
- American Iron and Steel GHG guidance

Certifications

- Responsible Steel International Standard & Certification
- Climate Bonds Initiative (Steel Criteria)
- The Steel Climate Standard

Landscape of standards and certification initiatives for methanol

Standards and Methodologies

- GH2 Green methanol
- GU-IMPCA
- TfS PCF Chemicals
- SBTi Chemicals
- ISO 14067
- ISO 14044
- GHG Protocol
- ISO 14040

Certifications

- ISCC Plus Chemicals
- ISCC EU
- RSB Global Fuel Certification
- Climate Bonds Chemicals
- TUV Rhineland low carbon fuels

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

Methanol- Standards and methodologies

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Summary of standards and methodologies for Methanol

Organisation/ initiative and version names	Market	Boundary	Pollutants covered	Emission thresholds	Requirements on source of carbon used defined[15]	Credits allotted for export of by-products	Credits allotted for exported energy	Credits allotted for offsets
IMPCA – Methanol Guideline May 2022	Voluntary, Global		GHGs	Unspecified	Yes	Yes	Yes	Yes
GH2 Protocol for Green Methanol Version 2.0 December 2023	Voluntary, Global		CO_2	0.3 $kgCO_2$/ $kgCH_3OH$	Yes	Yes	Unclear	Unclear
TfS PCF Guideline for Chemical Industry Version 2.1 February 2024	Voluntary, Global		GHGs	Unspecified	Yes	Yes	Yes	Yes
SBTi Chemicals	Voluntary, Global	To be launched in 2025.						

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

Methanol- Certifications

Summary of certification scheme for Methanol

Organisation/ initiative and version names	Market	Boundary	Certification validity	Emission thresholds	Requirements on source of carbon used defined[16]	Chain of custody model
ISCC Plus	Voluntary, Global		1 year	Unspecified	Yes	Mass balance
ISCC EU	Voluntary, Global		1 year	Unspecified	Yes	Mass balance
Climate Bonds Basic Chemicals Criteria April 2023	Voluntary, Global		3 years	Unspecified		Unclear
RSB Standard for Advanced Fuels Version 2.6 December 2023	Voluntary, Global		5 years	Unspecified	Yes	Book and claim *and* mass balance
TÜV Rheinland Renewable and Low-Carbon Hydrogen Fuels Version 2.1 March 2023	Voluntary, Global		1 year	94 gCO_2eq/MJ	Yes	Unclear

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

Conclusions and recommendations for enhancing market for hydrogen and derivates

Regulators should assess the impact of regulations on derivatives and ensure requirements extend across derivates

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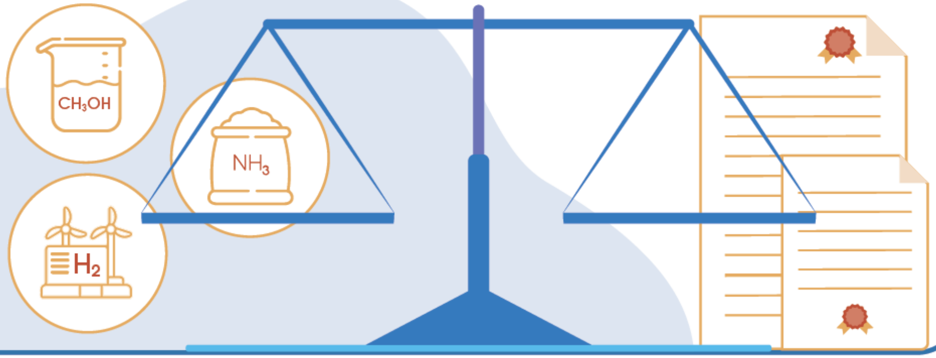
Regulatory framework design

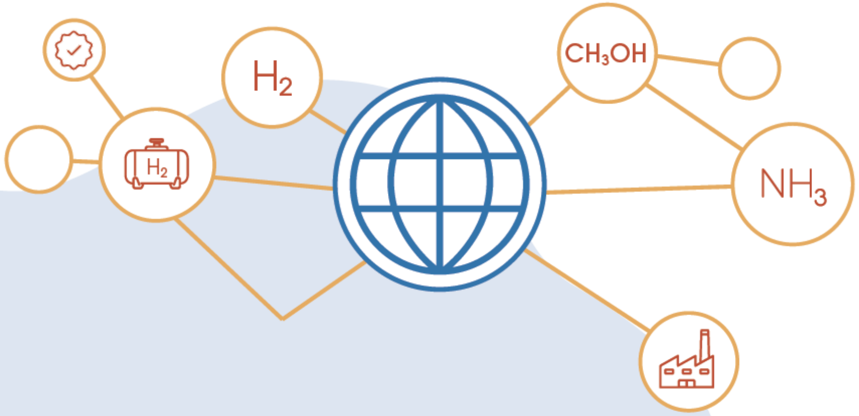
1

Regulators should consider the impact of the frameworks they are developing on the derivative commodity markets and should aim to ensure that the framework's requirements are robust to the characteristics and unique needs of those markets. This should include consideration of carbon-sourcing requirements for low-emission methanol.



2

Interoperability should be the goal of international efforts to align regulatory requirements or achieve mutual recognition of certification schemes. This interoperability should ideally extend to hydrogen and its derivatives.



Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

Making it easy for suppliers to understand and navigate requirements.

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Logistics of certification scheme development and management

3

To minimise the challenges for potential exporters in navigating regulatory and certification schemes, scheme owners and developers are encouraged to work directly with producers, for example through pre-certification activities, to increase producer understanding of what is required of them.

4

Transparency and specificity of requirements are essential in driving good outcomes via certification. Scheme owners and developers are encouraged to provide clear and detailed guidance on accepted methodologies (and underpinning requirements).

Sources: IRENA (2024), Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification.

International collaboration is vital in the pursuit of common (or interoperable) requirements and schemes

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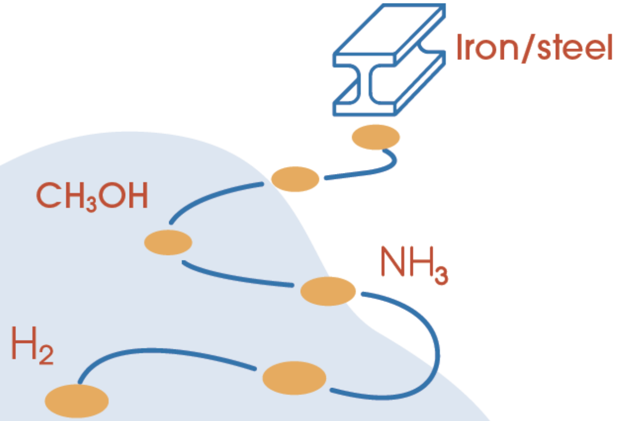
Value of and priorities for international collaboration

5

Where alignment of requirements is not possible, the focus on engagement via international fora should be on working towards interoperability of schemes.

6

There may be a role for agreements to develop common standards in the hydrogen, ammonia and methanol sectors, as was achieved in the iron and steel sector by the Steel Standards Principles.



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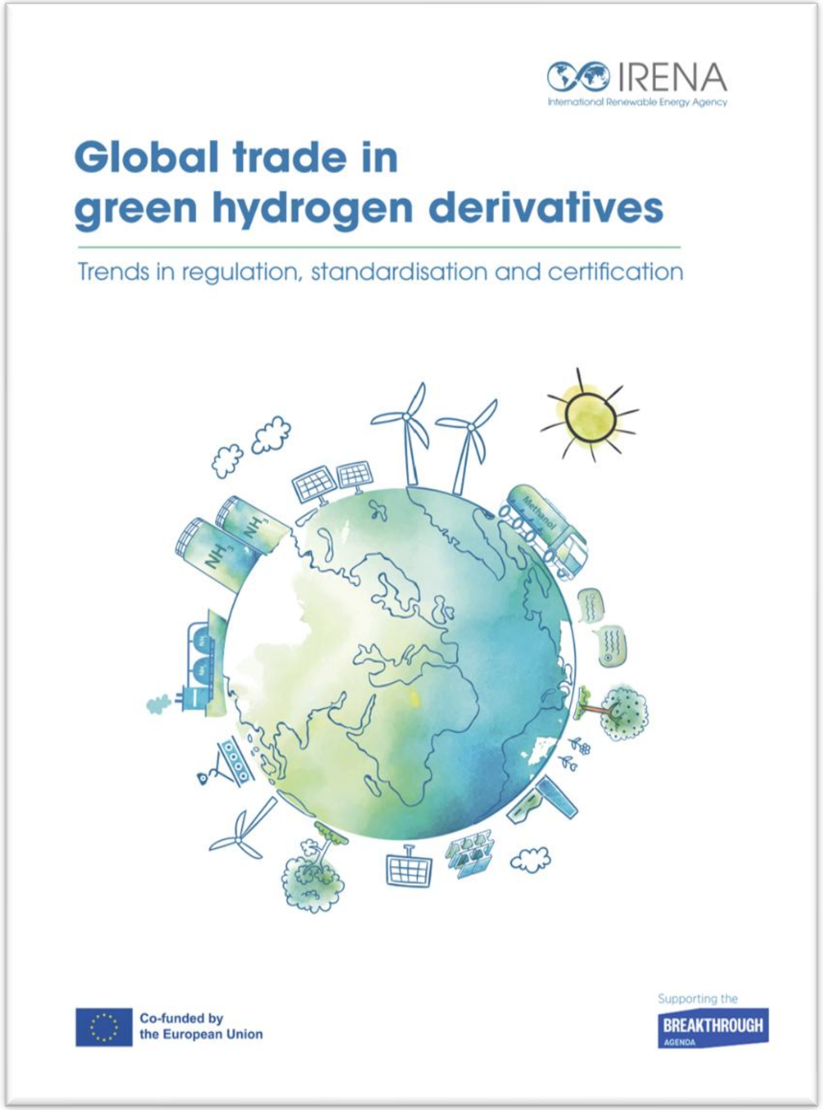

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