Creating a global hydrogen market and promoting trade

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IRENA Innovation and Technology Centre

Agenda

1. Introduction to IRENA
2. Setting the scene: the role for hydrogen in the global future energy system
3. Global trade in hydrogen and its derivatives
4. Standardisation and certification as key enablers for trade

Introduction to IRENA

IRENA serves 169 member countries

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- 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

IRENA provides analysis on the full hydrogen value chain

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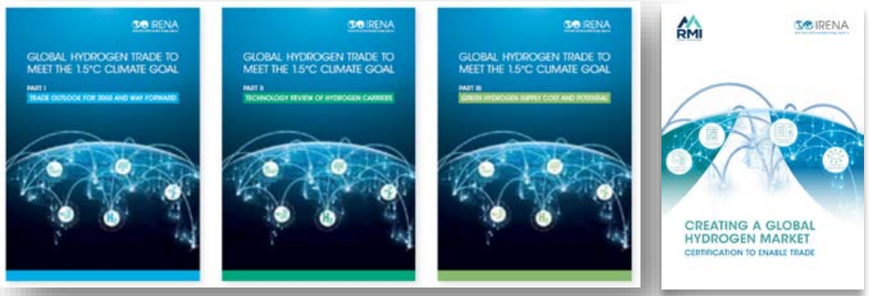
Supply

Sector coupling

Trade



Demand

Policies & cross cutting

IRENA's Collaborative Framework on Green Hydrogen brings together the global community

- Global platform to expedite the deployment of hydrogen.
- CFGH addresses critical issues faced by members in the hydrogen market, currently co-facilitated by Germany and the United Arab Emirates
- In 2023, broad representation with 144 participants from IRENA's membership.
- Expertise shared by external experts and insights from IRENA's analyses.
- Discussions include country interventions for in-depth understanding of global developments.
- In 2024, the CFGH focuses on the role of hydrogen derivatives

Source: IRENA (2023): International co-operation to accelerate green hydrogen deployment.

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Setting the scene: the role for hydrogen in the global future energy system

In IRENA's 1.5°C Scenario, hydrogen complements direct electrification and energy efficiency

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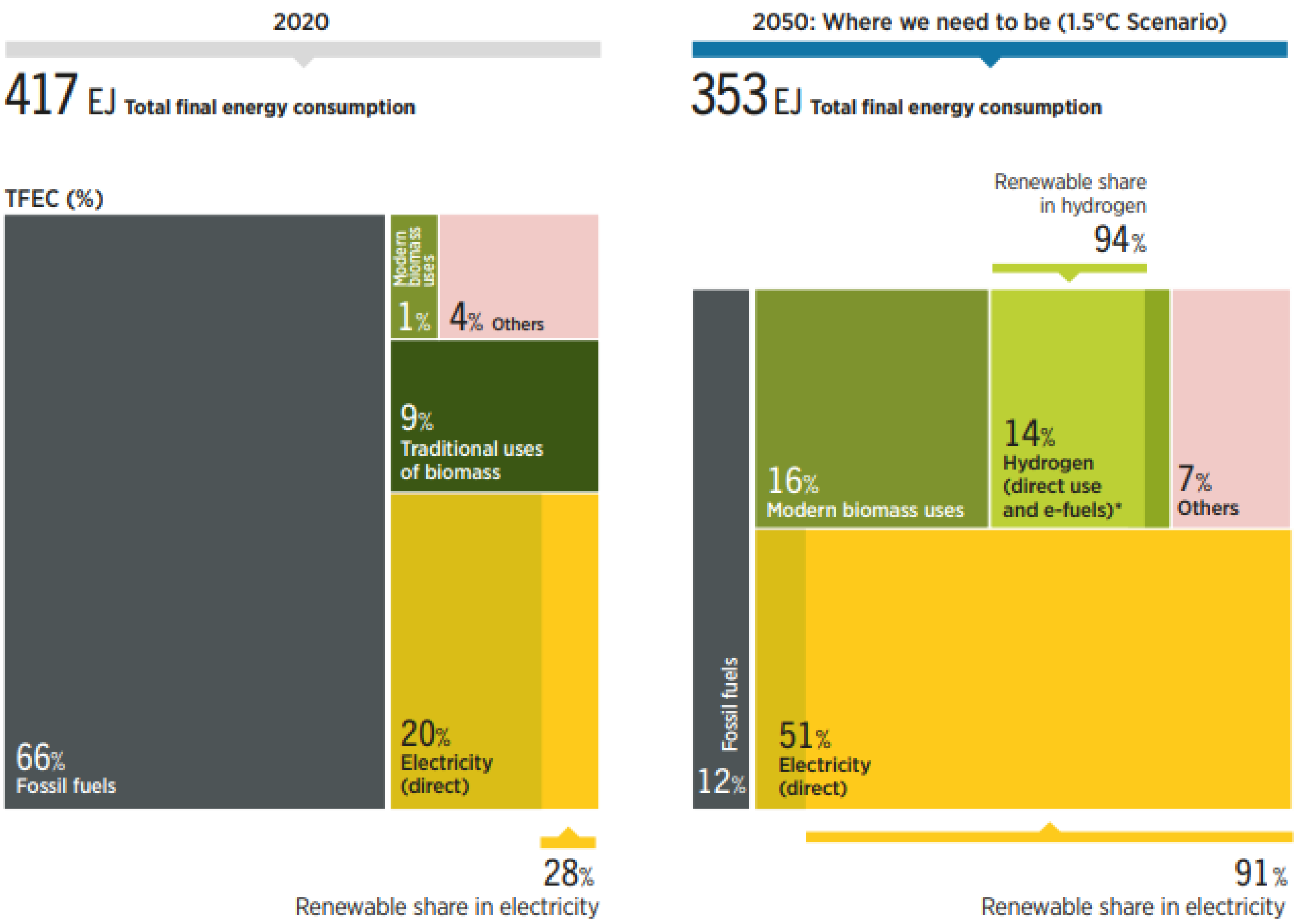
Breakdown of total final energy consumption by energy carrier in 2020 and 2050 under IRENA's 1.5°C Scenario:

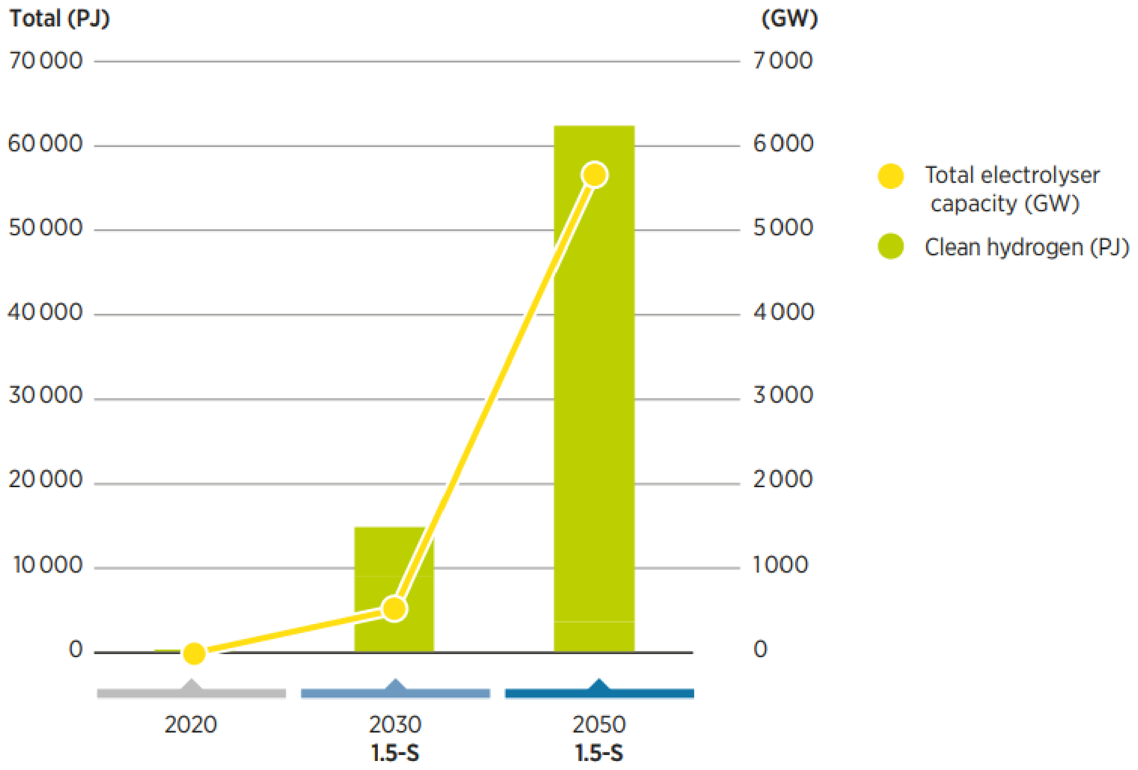


- By 2050, **electricity becomes the main energy carrier**, accounting for more than half of the global final energy consumption.
- Hydrogen and hydrogen derivatives make up around **14% of total final energy consumption by 2050**.
- **94% of hydrogen production** should **come from renewables.**

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.**
- From **~ 1 GW to >5700 GW** electrolyser capacity by 2050.

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

Green hydrogen costs vary most strongly with electrolyser cost and input electricity costs

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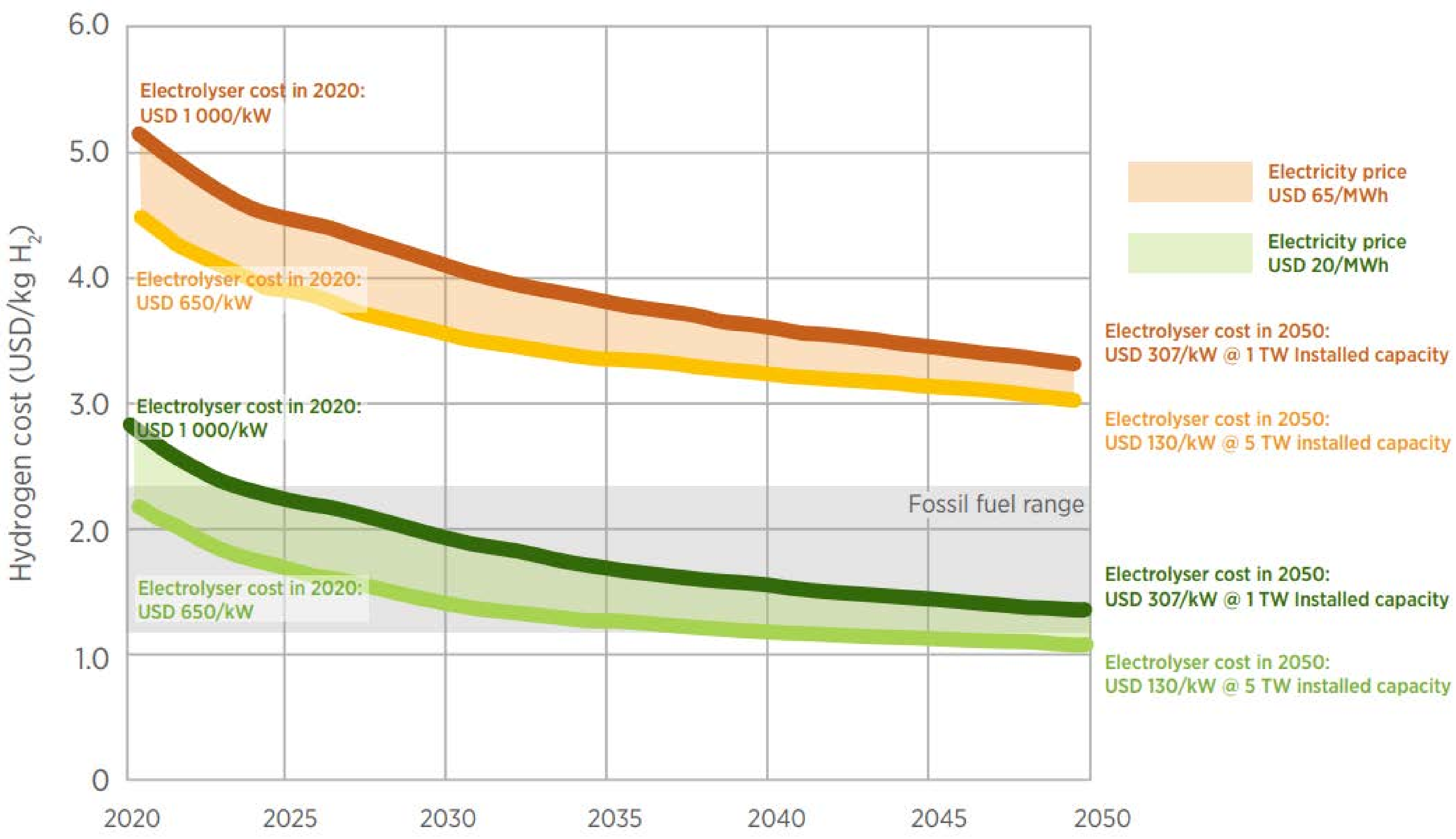

Source: IRENA (2022): Global hydrogen trade to meet the 1.5C goal. Part I: Trade outlook for 2050 and way forward.

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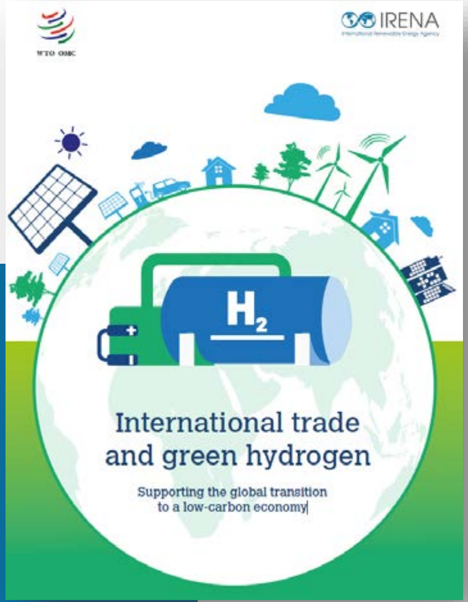
Global trade in hydrogen and its derivatives



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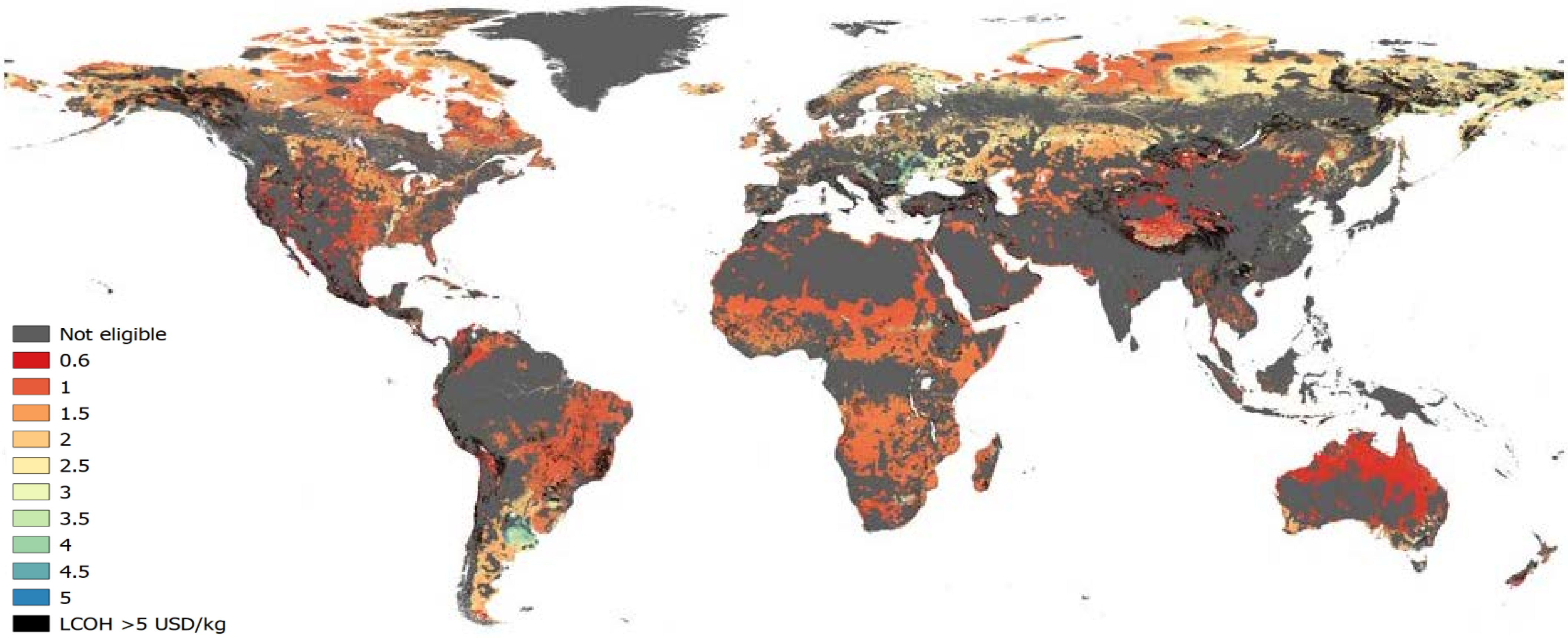
Differences in localised levelised cost of hydrogen in 2050 may drive competitive advantages



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

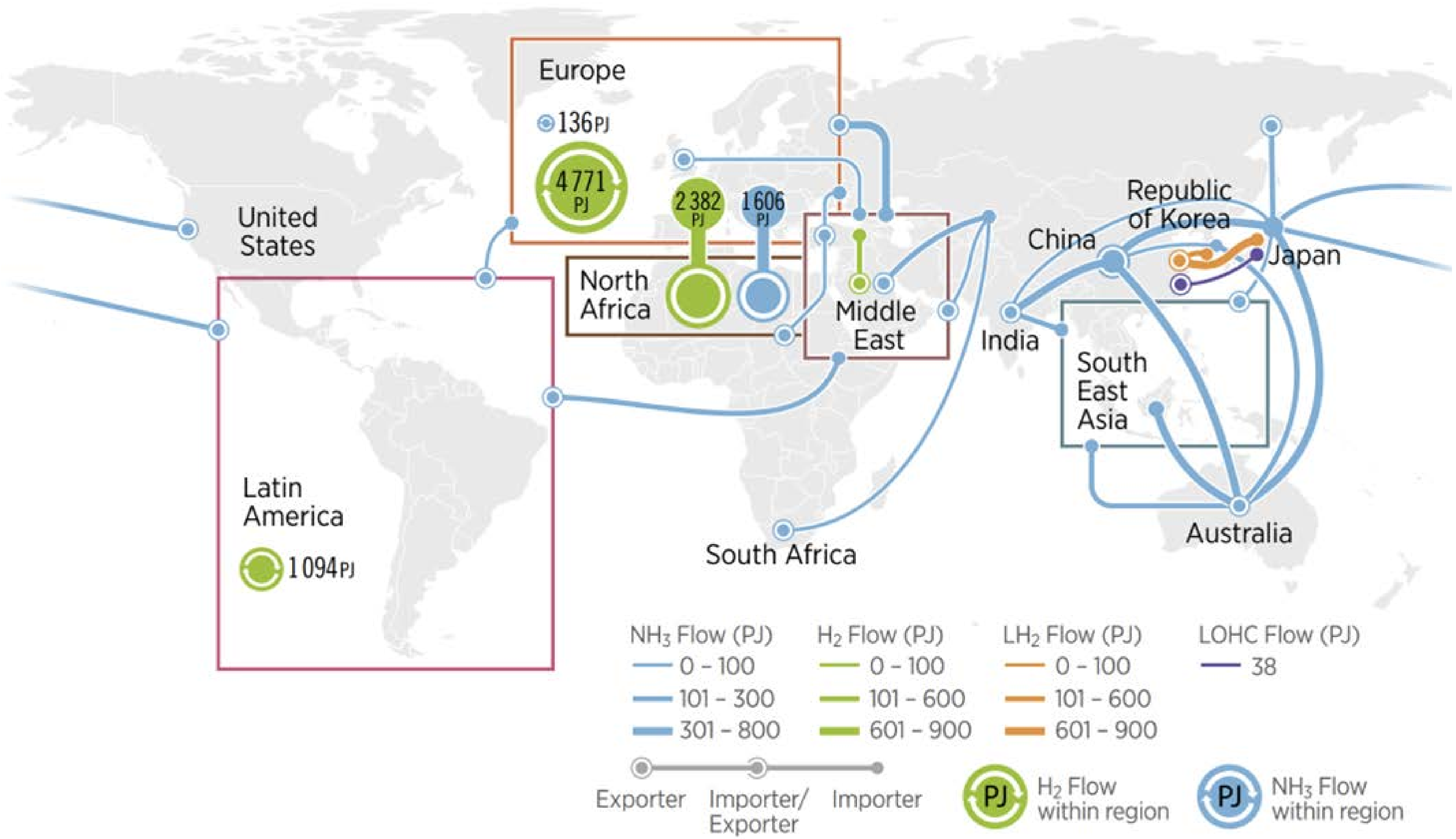
Source: IRENA (2022): Global hydrogen trade to meet the 1.5C goal. Part I: Trade outlook for 2050 and way forward.

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

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.

Tracking global imports in hydrogen and derivatives (ammonia and methanol)

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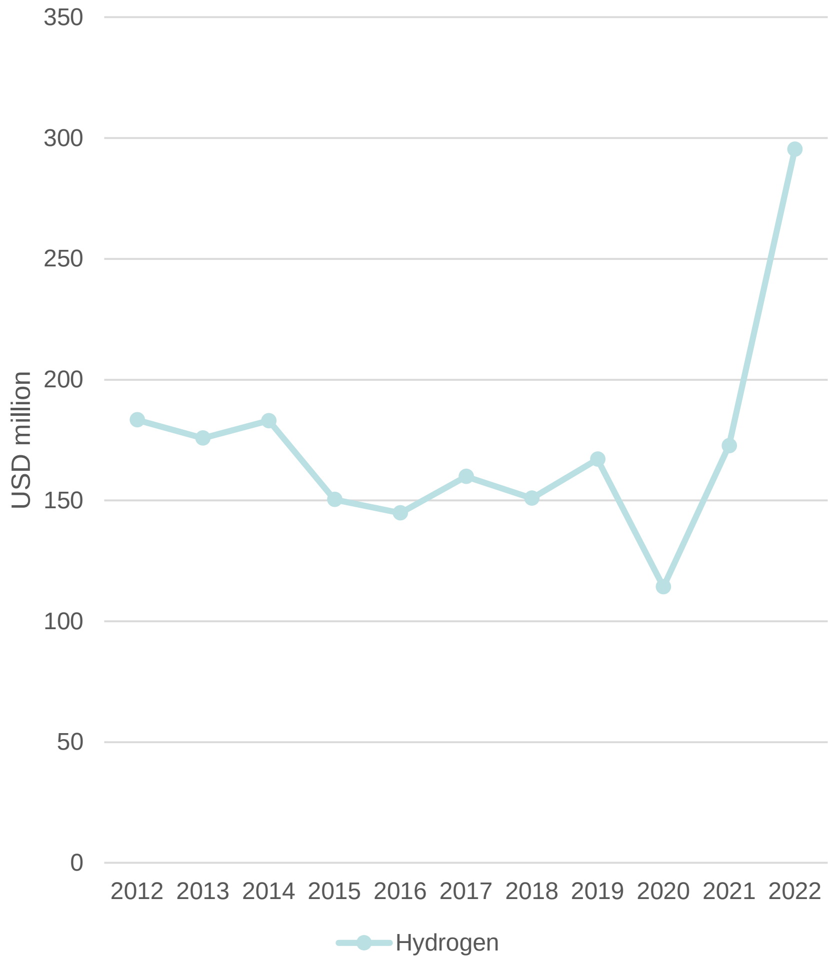

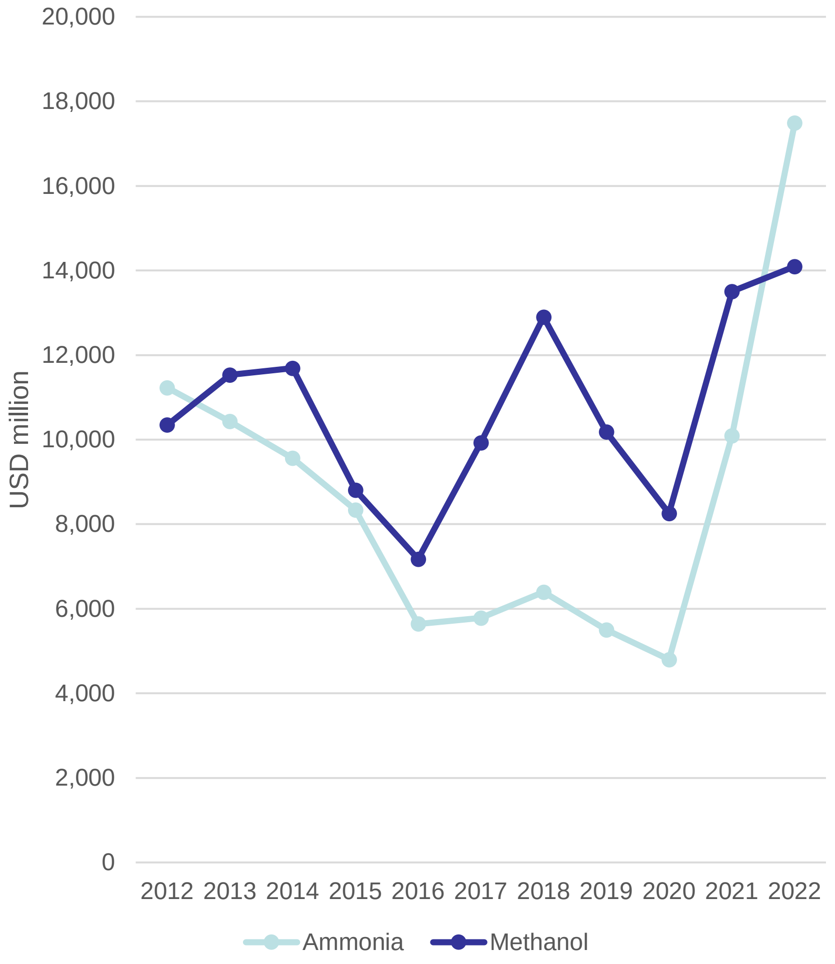

- Trade of hydrogen and derivatives is **increasing since 2020.**
- Current trade of **hydrogen is rather small compared to ammonia and methanol** – almost two orders of magnitude.
- Hydrogen in the order of 300 million USD, while **ammonia and methanol** in the order of **18 and 14 billion USD** respectively in 2022.

Source: WTO and IRENA (2023): International trade and green hydrogen: Supporting the global transition to a low-carbon economy.

Geography of trade in hydrogen and derivatives: regional vs global

Top import markets for ammonia and top three suppliers, 2021

Source: WTO Secretariat Analytical Database based on data originally sourced from the WTO Integrated Database, UN Comtrade and the Trade Data Monitor.

Importer	US$ million	Suppliers (percentage share in import market)
India	1,577.5	Saudi Arabia, Kingdom of (23), Qatar (22), Ukraine (13)
United States	1,352.2	Canada (48), Trinidad and Tobago (47), Algeria (1)
Morocco	769.6	Russian Federation (50), Trinidad and Tobago (36), Algeria (6)
Korea, Republic of	746.7	Indonesia (40), Saudi Arabia, Kingdom of (19), Trinidad and Tobago (12)
Belgium	521.0	Russian Federation (33), Trinidad and Tobago (24), Algeria (20)

- **Trade in hydrogen** is currently concentrated in a few economies and largely **regional**.
- Current trade landscape for **ammonia** and **methanol** is **more global**.

- Development of green hydrogen markets will lead to growth in trade in hydrogen and derivatives as well as affect the geography of trade.

Top import markets for methanol and top three suppliers, 2021

Source: WTO Secretariat Analytical Database based on data originally sourced from the WTO Integrated Database, UN Comtrade and the Trade Data Monitor.

Importer	US$ million	Suppliers (percentage share in import market)
China	3,367.0	United Arab Emirates (39), Oman (25), Saudi Arabia, Kingdom of (11)
India	996.1	Saudi Arabia, Kingdom of (31), Qatar (19), Oman (15)
Netherlands	929.7	Trinidad and Tobago (20), Equatorial Guinea (19), United States (13)
United States	863.4	Trinidad and Tobago (55), Canada (20), Equatorial Guinea (10)
Korea, Republic of	791.7	United States of America (38), Trinidad and Tobago (25), Oman (16)

Source: WTO and IRENA (2023): International trade and green hydrogen: Supporting the global transition to a low-carbon economy.

Trade in goods and services across the green hydrogen supply chain

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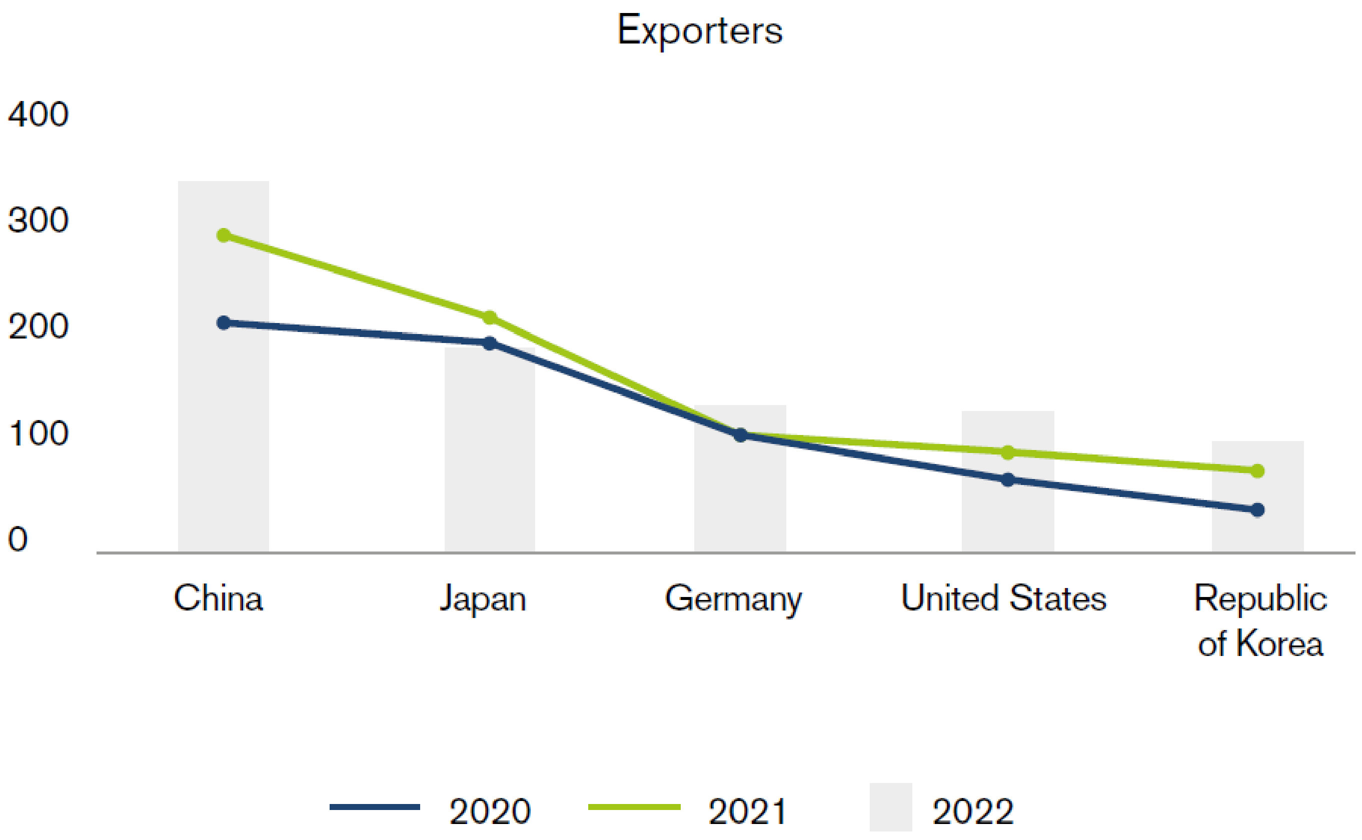
	Renewable energy production	Hydrogen & hydrogen derivatives production	Transport, storage and reconversion	Use
EQUIPMENT	• Renewable energy generation equipment, e.g., solar panels, wind turbines, etc. • Electric equipment.	• Electrolysers • Compressors, valves, flow control, metering and related equipment • Ammonia, methanol, direct reduced iron production plants.	• Piping and storage systems. • Compressors, valves, flow control, metering and related equipment. • Hydrogen, ammonia, methanol, hot briquetted iron transport vessels.	• Ammonia, methanol, production plants. • Direct reduction furnaces for iron production. • Fuel cell systems. • Hydrogen-ready (industrial) boilers • Hydrogen-ready gas turbines for power generation. • Fuel cell electric vehicles. • Ammonia, methanol and hydrogen storage equipment.
SERVICES	• Design • Engineering • Related construction • Operation and management		• Transportation and storage services • Related construction (e.g., port terminals)	• Wholesale and retail (e.g., hydrogen stations) • Marketing
	R&D, technical testing and analysis, consulting and training, various professional and business services			

Source: WTO and IRENA (2023): International trade and green hydrogen: Supporting the global transition to a low-carbon economy.

Electrolysers as key technology in green hydrogen supply chain: Top exporters (US$ million)



- Trade in electrolysers will play a key role in fostering innovation, scale economies and cost reductions
- Global imports of electrolysers (together with certain other machines) amounted to US$ 1.62 billion in 2022, following two years of strong growth
- The top five suppliers account for more than three-quarters (76%) of global imports

Note: Electrolysers are included under Harmonized System (HS) subheading 854330: Machines and apparatus for electroplating, electrolysis or electrophoresis. It should be noted that the reported values represent trade in electrolysers and other machines for electroplating and electrophoresis

Source: WTO and IRENA (2023) International trade and green hydrogen: Supporting the global transition to a low-carbon economy.

Summary - Five key actions to foster hydrogen trade

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1. Addressing trade by **reducing tariffs and non-tariff barriers** on green hydrogen, electrolysers, derivatives and other products along the supply chain.

2. Developing **sound quality infrastructure** by adopting national measures based on international standards and engaging in international standardization.

3. Implementing support policies via **targeted and non-discriminatory environmental subsidies** to help sustain growth in electrolyser capacity.

4. Using **sustainable government procurement** by purchasing low-carbon goods and services and stimulating innovative solutions.

5. Increasing **international cooperation** through cross-borders dialogue and increased in joint capacity building programmes.

Source: WTO and IRENA (2023): International trade and green hydrogen: Supporting the global transition to a low-carbon economy.

Standardisation and certification as key enablers

Standards and certification definitions

	Standard	Certification
Explanation	Formal methodology or guidance stipulates which rules must be used to determine the characteristics of a system and may also define the characteristics of a system itself	Certification is the formal process where an accredited third-party body ensures a system adheres to a specified standard, and issues certificates as proof of adherence.
Key elements	Procedures for evaluating characteristics and conformity, terms and definitions, criteria for compliance	Assessment process, third-party involvement, compliance to standards, validity period

Source: IRENA (2014): Quality Infrastructure for Renewable Energy Technologies.

ISO standard 19870 was unveiled at COP28

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ISO/TS 19870:2023

Hydrogen technologies

Methodology for determining the greenhouse gas emissions associated with the production, conditioning and transport of hydrogen to consumption gate

- The release of ISO 19870 is a critical step for efforts to align internationally on agreed ways to harmonise expectations for the global hydrogen market.

- The standard concerns an agreed methodology for measuring the emissions intensity of hydrogen volumes.

News Article | 8 December 2023

New ISO standard on hydrogen unveiled at COP28

During COP28 in Dubai, the International Organization for Standardization (ISO) unveiled a new technical specification (ISO/TS 19870) as a foundation for harmonisation, safety, interoperability and sustainability across the hydrogen value chain.

Source: ISO (ISO/TS 19870:2023) & European Hydrogen Observatory

COP28 Declaration of Intent on Hydrogen

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MUTUAL RECOGNITION OF CERTIFICATION SCHEMES FOR RENEWABLE AND LOW-CARBON HYDROGEN AND HYDROGEN DERIVATIVES

"In recognition of the considerations listed above, declare their intention as follows:

- 1. In order to pave the way for development of a global market renewable and low-carbon hydrogen and hydrogen derivatives, the Participants seek to work towards mutual recognition of their respective certification schemes;
- ……….
- 4. The Participants may consider further steps to support the process of mutual recognition of certification schemes, including by taking into account the adoption of or consistency with globally recognised standards, such as the ISO methodology for determining the GHG emissions associated with the production and transport of hydrogen;"

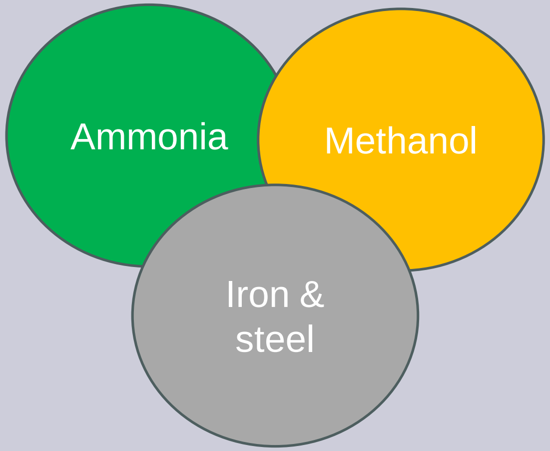
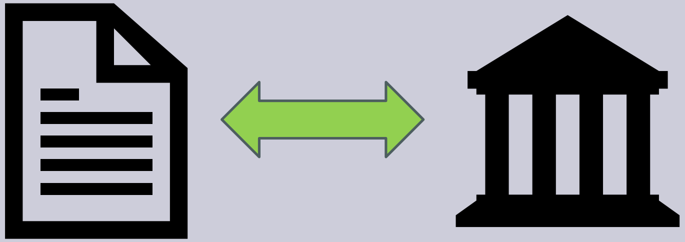
COP28
UAE

Source: COP28 (COP28 Declaration Of Intent – Hydrogen)

Upcoming report: A comparison of accounting guidelines, standards, and certification for hydrogen and its derivatives

Scope of analysis:

1) Mapping existing approaches and initiatives concerning accounting methods, standards, and certification schemes on the related carbon footprints.
2) Identifying the gaps and opportunities of improvement concerning those existing initiatives.

To Update	Expand Analysis	Link with Regulations
 Launched in January 2023		 Look into compatibility of existing standards and certification schemes with existing/new regulatory schemes in major markets (USA, EU, Japan, RoK)

Existing voluntary certification schemes have fundamental differences that make interoperability difficult

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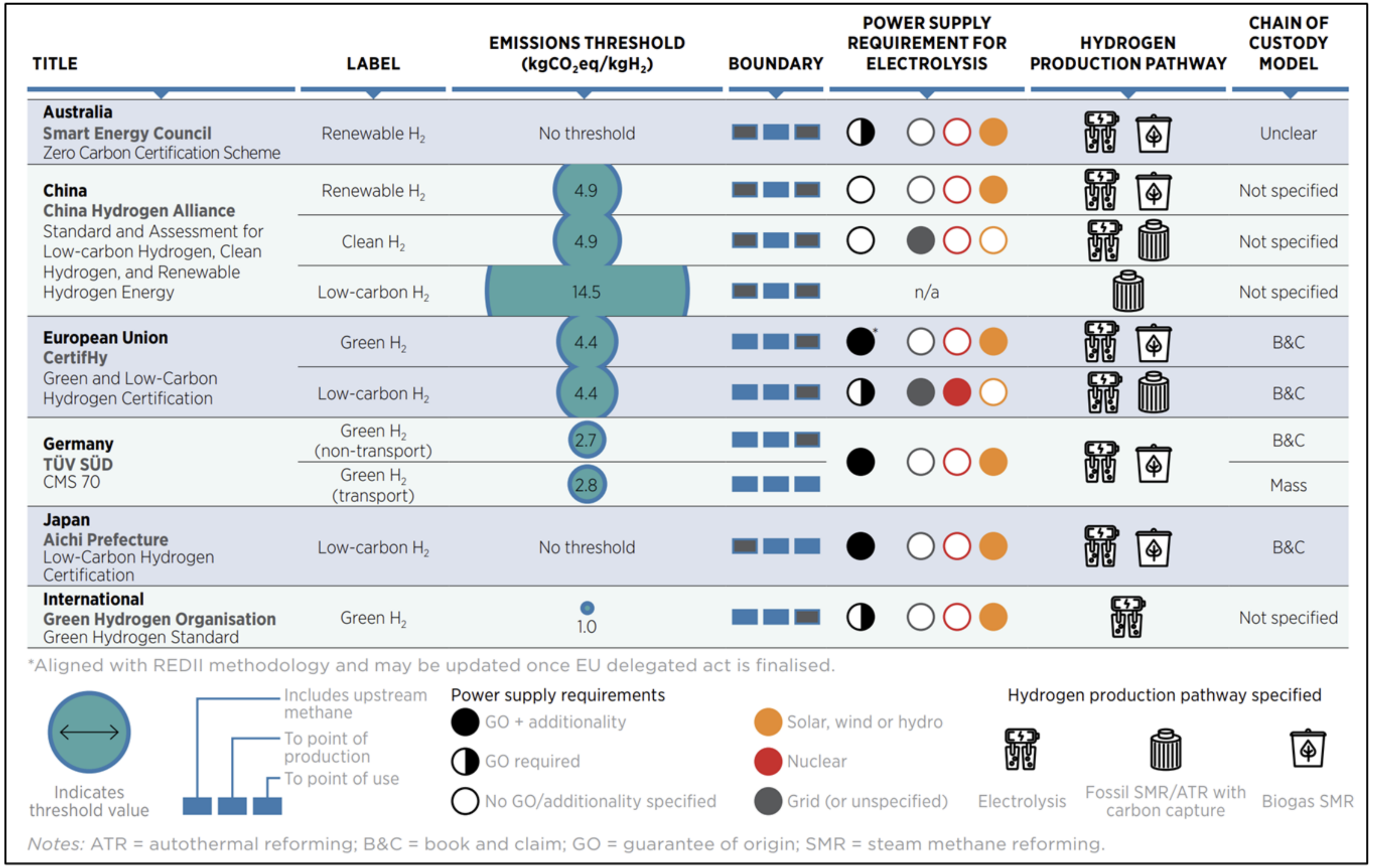

TITLE	LABEL	EMISSIONS THRESHOLD ($kgCO_2eq/kgH_2$)	BOUNDARY	POWER SUPPLY REQUIREMENT FOR ELECTROLYSIS	HYDROGEN PRODUCTION PATHWAY	CHAIN OF CUSTODY MODEL
Australia **Smart Energy Council** Zero Carbon Certification Scheme	Renewable H_2	No threshold				Unclear
China **China Hydrogen Alliance** Standard and Assessment for Low-carbon Hydrogen, Clean Hydrogen, and Renewable Hydrogen Energy	Renewable H_2	4.9				Not specified
	Clean H_2	4.9				Not specified
	Low-carbon H_2	14.5		n/a		Not specified
European Union **CertifHy** Green and Low-Carbon Hydrogen Certification	Green H_2	4.4		*		B&C
	Low-carbon H_2	4.4				B&C
Germany **TÜV SÜD** CMS 70	Green H_2 (non-transport)	2.7				B&C
	Green H_2 (transport)	2.8				Mass
Japan **Aichi Prefecture** Low-Carbon Hydrogen Certification	Low-carbon H_2	No threshold				B&C
International **Green Hydrogen Organisation** Green Hydrogen Standard	Green H_2	1.0				Not specified

*Aligned with REDII methodology and may be updated once EU delegated act is finalised.

Notes: ATR = autothermal reforming; B&C = book and claim; GO = guarantee of origin; SMR = steam methane reforming.

- A wide range of certification schemes are in development for hydrogen
- The **system boundaries, chain of custody models** and and **accounting methodologies** in place for these vary widely
- We are now working to update this landscape to account for **certification schemes for the derivative commodities**

Source: IRENA and RMI (2023): Creating a global hydrogen market: Certification to enable trade.

Regulations mature for hydrogen, lag for derivatives

	Hydrogen	Ammonia	Methanol	Iron and steel
European Union	**REDII/RED III:** <3.4 kg/ kg CO_2-eq/kg H_2. Criteria on temporal, geographical correlation and additionality. **There are also additional criteria on sourcing of carbon for methanol** **EU Taxonomy (For hydrogen):** <3 kg/ kg CO_2-eq/kg H_2			**EU Taxonomy:** <1331 kg CO_2-eq/kg Hot Metal
India	**Clean Hydrogen Standard:** From renewable energy with emissions intensity <2 kg CO_2-eq/kg H_2			
Japan	**Basic Hydrogen Strategy**: Production with emissions intensity <3.4 kg CO_2-eq/kg H_2			
Republic of Korea	**Clean Hydrogen Certification Mechanism:** Production with emissions intensity < 4 kg CO_2-eq/kg H_2			
United Kingdom	**UK Low Carbon Hydrogen Standard:** with emissions intensity <2.4 kg CO_2-eq/kg H_2			
United Kingdom	**Renewable Transport Fuel Obligation** Production with emissions intensity < 4 kg CO_2-eq/kg H_2			
United States	**Production Tax Credit:** Emissions intensities <0.45, 0.45-1.5, 1.5-2.5, 2.5-4 kg CO_2-eq/kg H_2			
California (United States)	**Low-Carbon Fuel Standard:** Default values of emissions limits ranging from 1.3 to 18.1 kg CO_2-eq/kg H_2			

[1] Not specially tied to hydrogen-based production routes.
[2] The UK RTFO is applicable to ammonia and methanol for maritime and aviation fuels.

Operational | Under Development | No taxonomy

Conclusions

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- **Hydrogen and its derivatives have an essential role to play in the energy transition**. The derivative commodity value chains are well developed and underpin everyday goods.

- Current trade of **hydrogen is rather small compared to ammonia and methanol** – almost two orders of magnitude, and the derivatives will continue to play a major role in the trade of green hydrogen.

- Regulatory frameworks, standards and certification schemes are **emerging for hydrogen but are less well developed for the derivatives**. They are essential market enablers – playing a vital role in de-risking.

- Heterogeneities in regulatory requirements and the associated certification schemes increase **complexity for producers**. Interoperability is key to international market development.

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