International Energy Agency

Perspectives and Challenges for Clean Hydrogen

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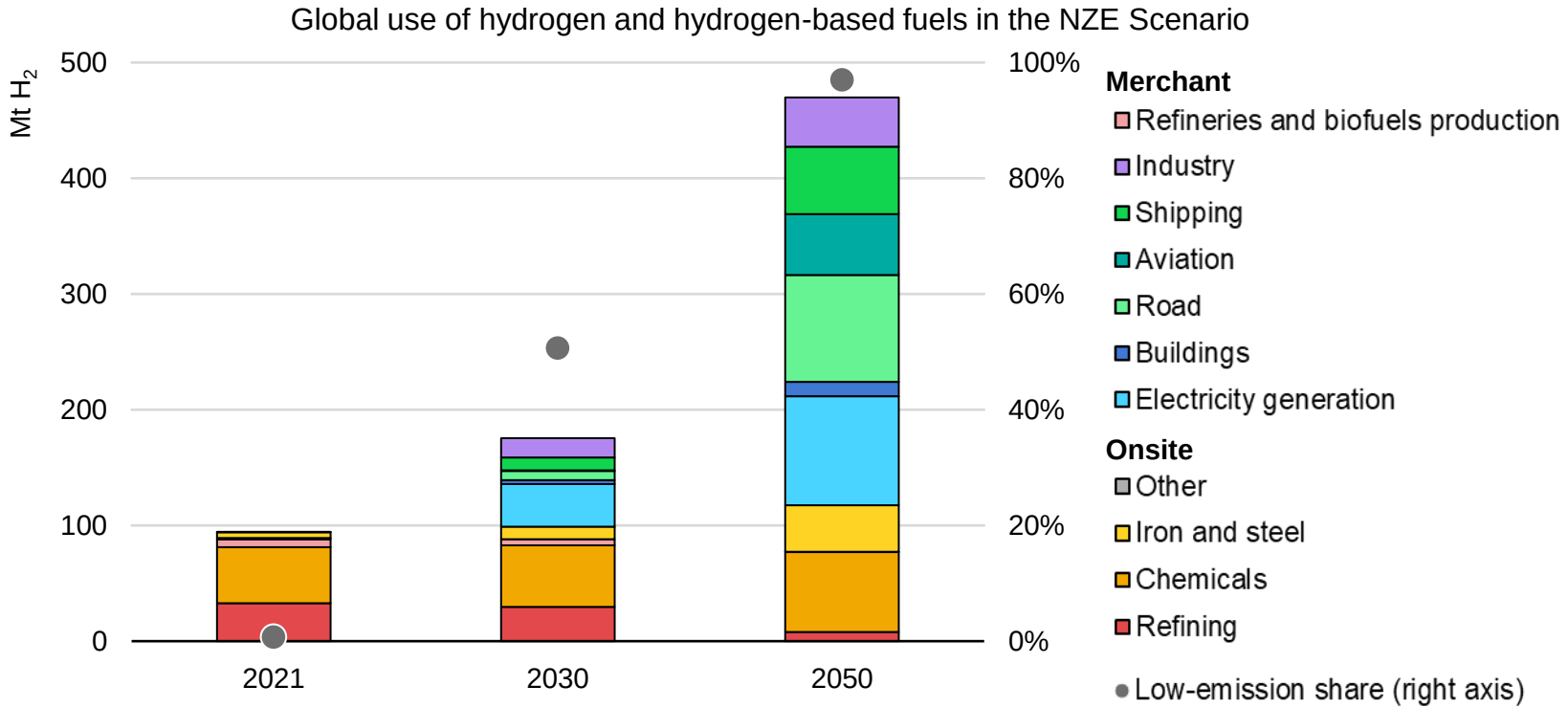
Momentum keeps growing, with new drivers emerging

- Hydrogen is widely recognised as an important option in supporting climate ambitions; it can also help enhance energy security

- Net-zero pledges are boosting hydrogen interest, further bolstered by the global energy crisis:
  - Five new national strategies were adopted in 2023
  - Large projects are starting to reach FID and major players are signing off-take agreements
  - Growing international cooperation to develop hydrogen trade

- Adoption of low-emission hydrogen as energy vector is at an early stage and needs regular and effective tracking

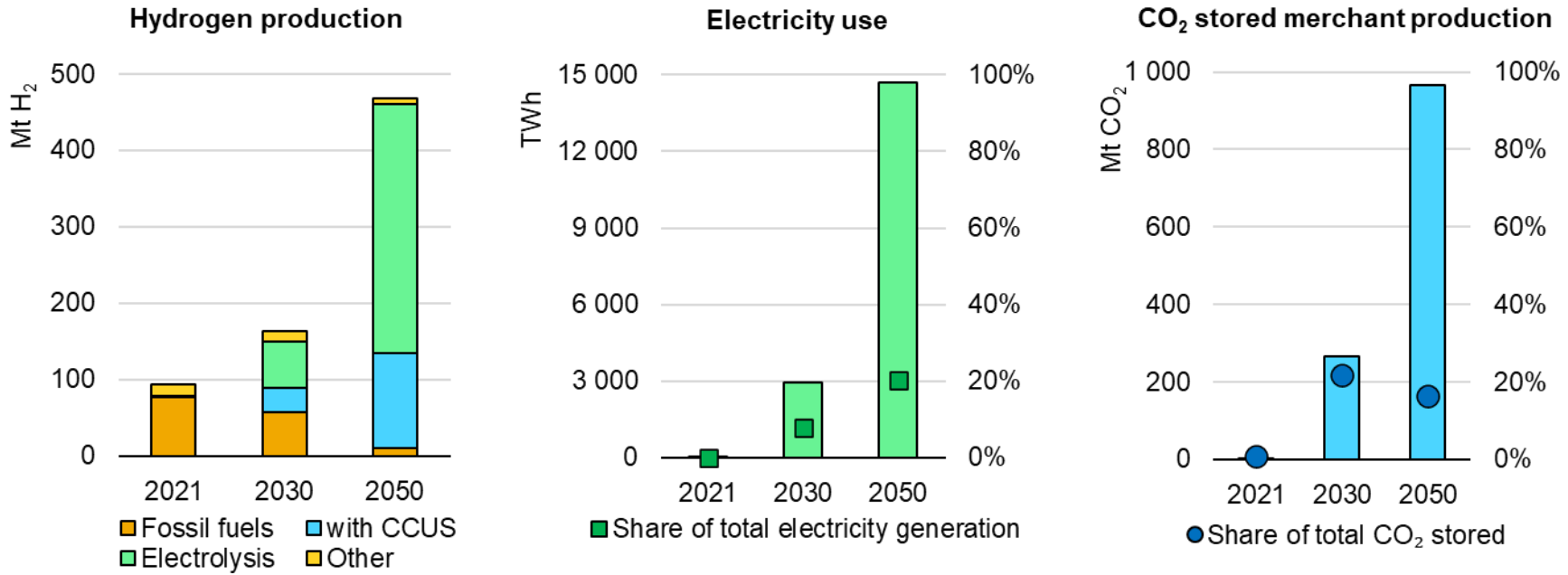
Hydrogen is a key pillar for net zero across the energy system



Hydrogen demand jumps fivefold by 2050, expanding beyond refineries and the chemical industry to new uses in long-distance transport, electricity generation and steel making

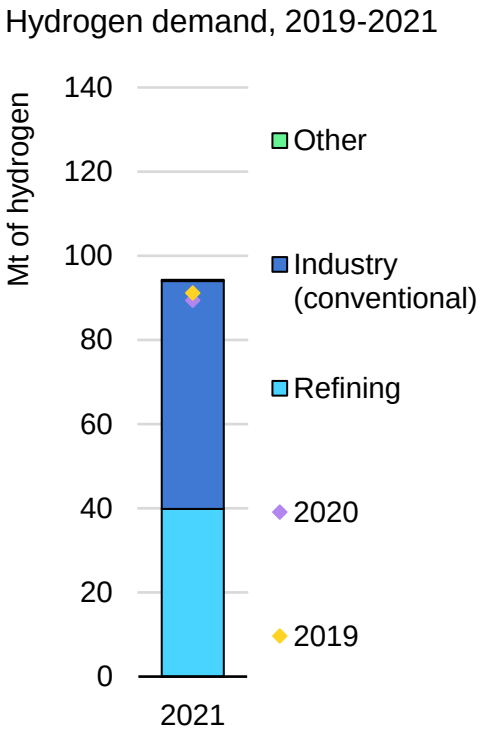
Rapid scale up of supply chains for low-carbon hydrogen needed

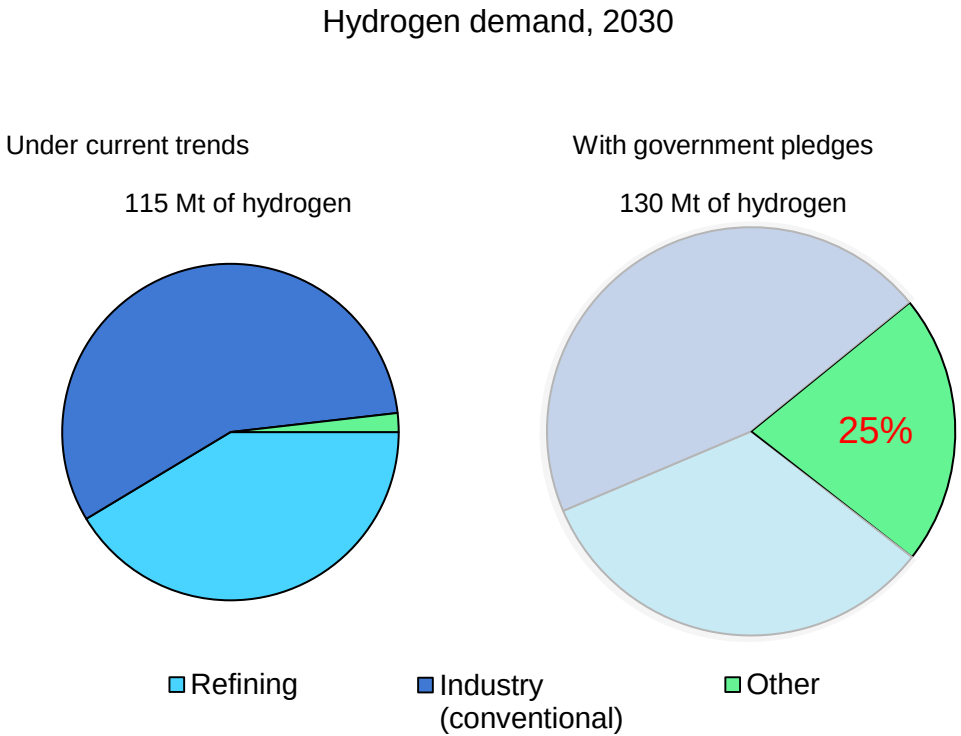
Global hydrogen production, electricity use for electrolysers and CO_2 stored from merchant hydrogen production in the NZE



By 2050, hydrogen production in the NZE is almost entirely based on low-emission technologies, with electrolysers accounting for around 70% of global production, and natural gas in combination with CCUS for almost 30%

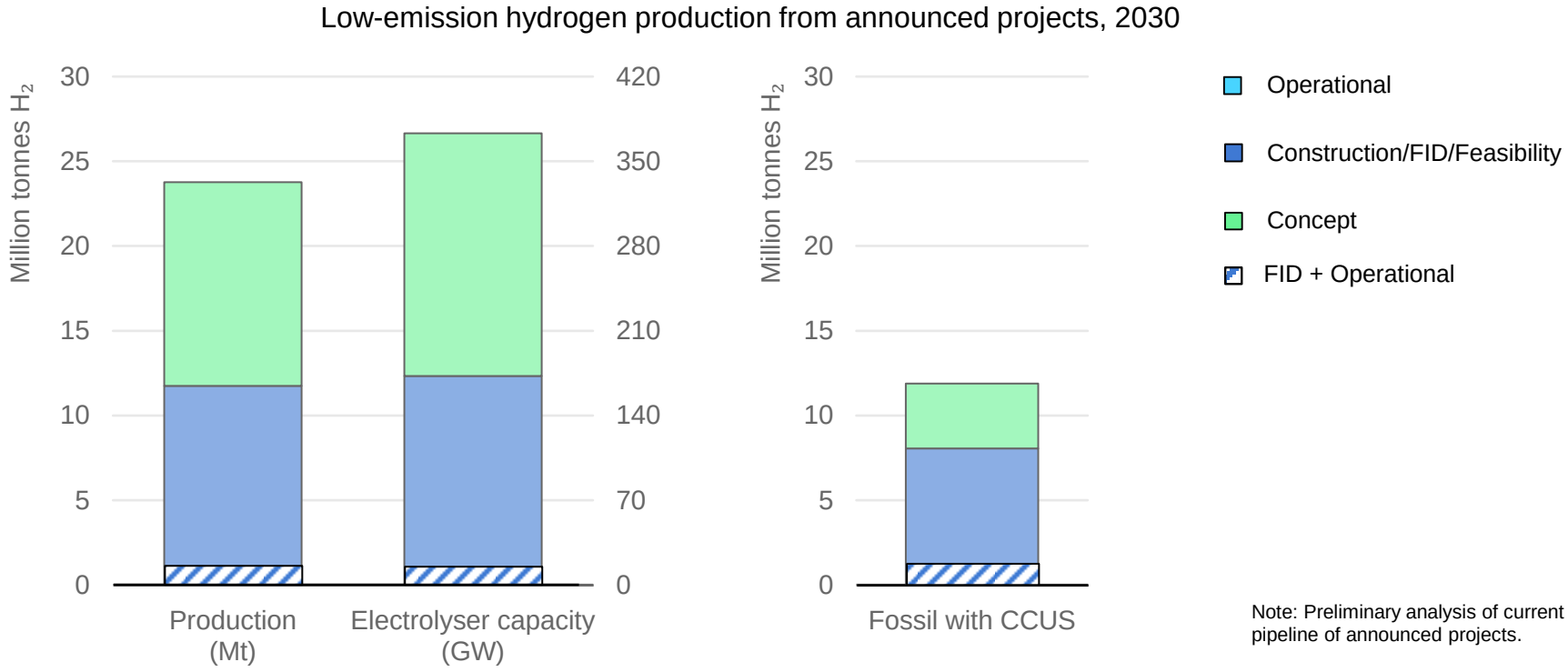
Demand is growing, with positive signals in key applications





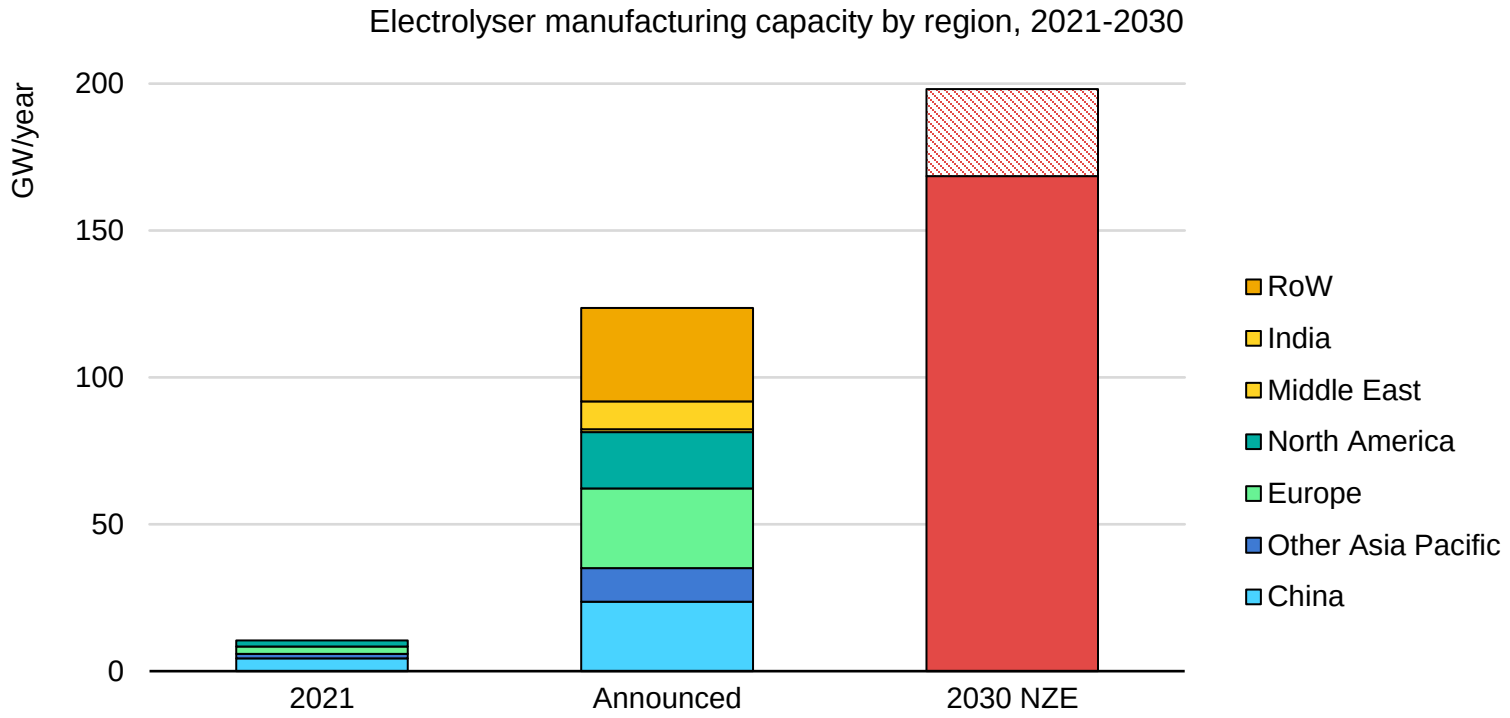
There are plans to increase hydrogen use in heavy industry, transport and power generation, but ambitious policies are needed for hydrogen to play its role in meet government climate pledges

An increasing project pipeline for low-emission hydrogen production



Low-emission hydrogen could reach 20-36 Mt per year by 2030. However, just a few projects are under construction or have reached FID due to uncertainties about demand, regulation and infrastructure

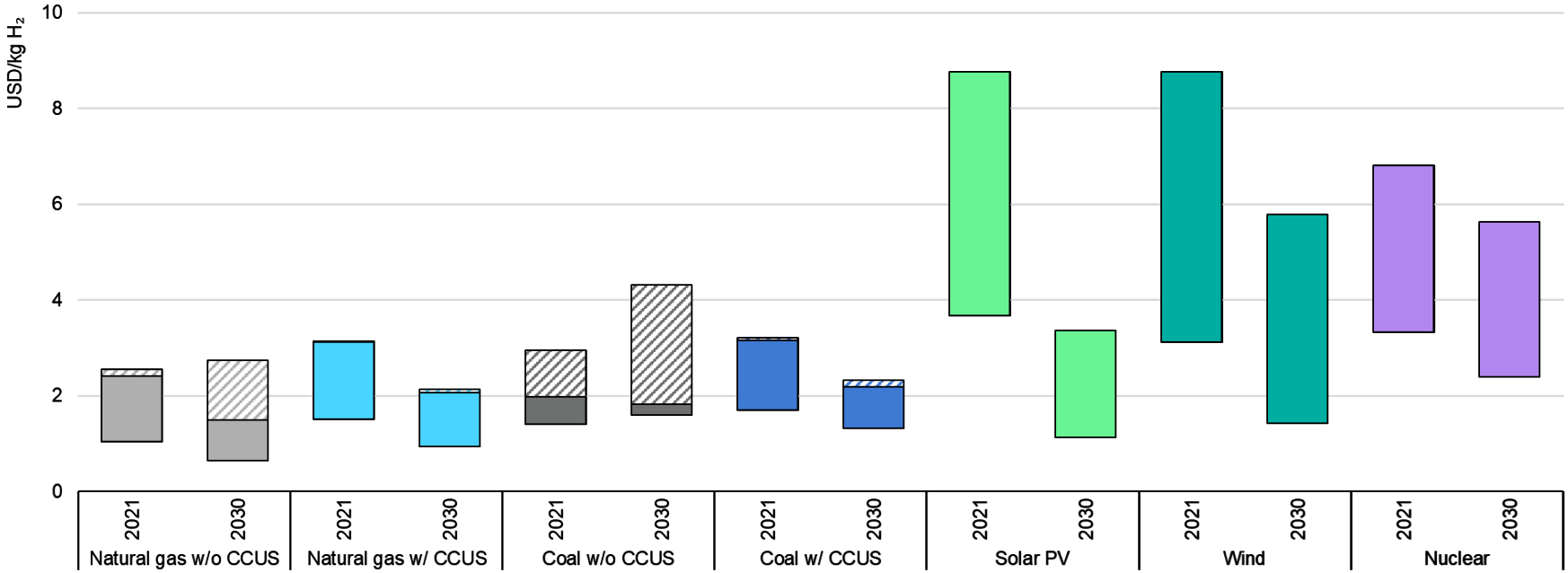
A new energy economy: the case of electrolyser manufacturing



Electrolyser manufacturing capacity could reach 125 GW per year by 2030.
This would be more than enough to support planned electrolyser projects and government targets

Low-emission hydrogen costs are falling

Hydrogen production cost for different production routes in the NZE Scenario, 2021-2050

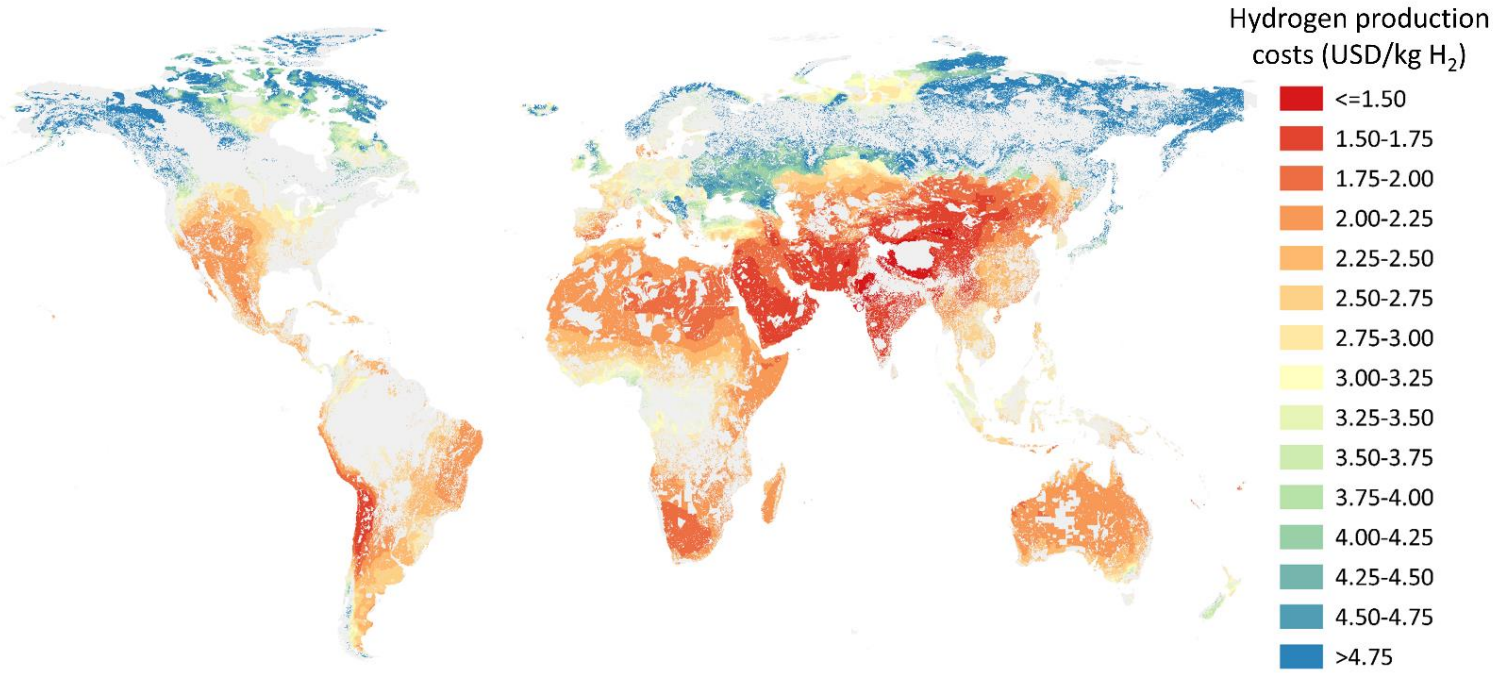


The dashed area represents the CO_2 price impact, based on USD 15-140/t CO_2.

Renewable hydrogen could become cost competitive with hydrogen from unabated fossil fuels within this decade

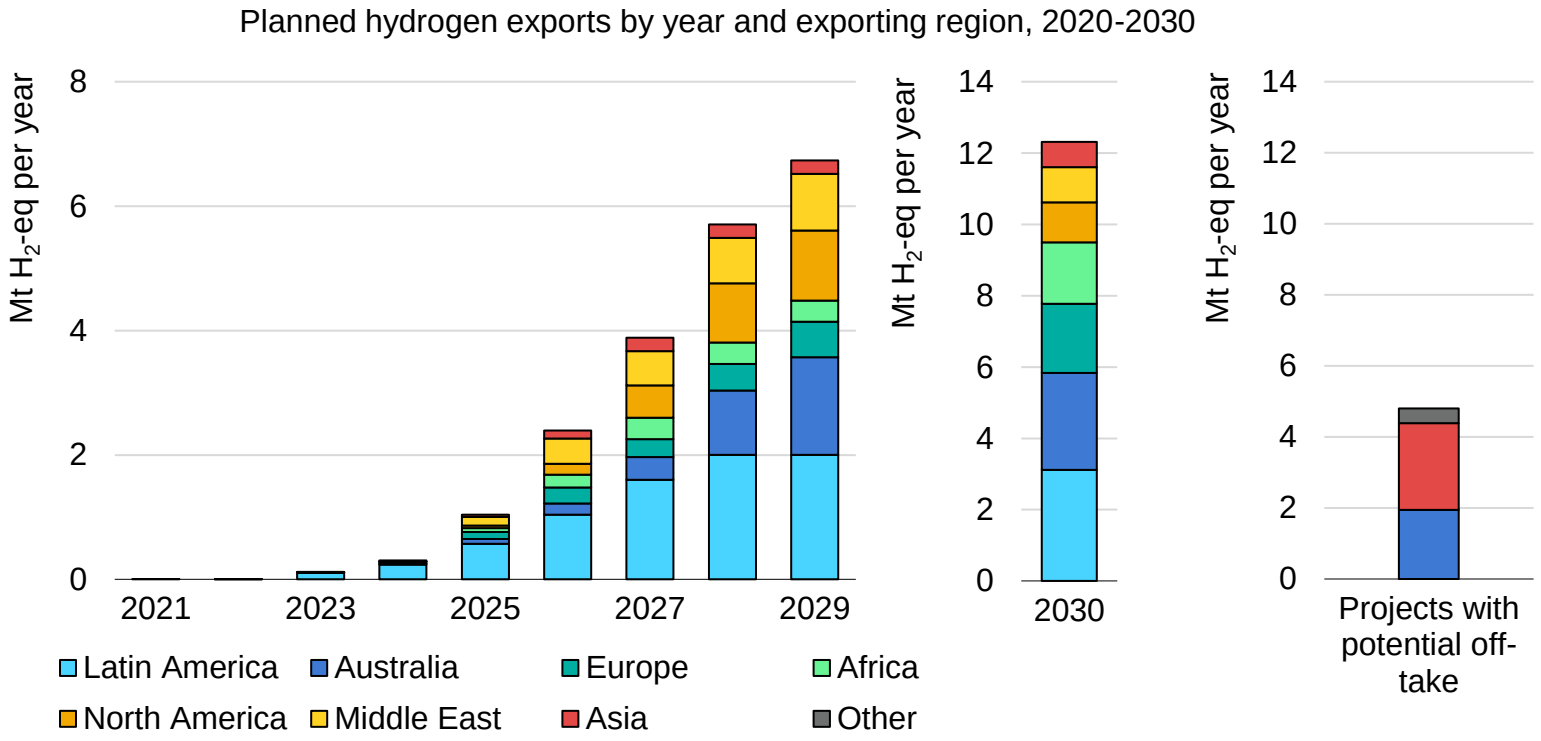
Renewable hydrogen production costs are set to decline

Hydrogen production cost from hybrid solar PV and wind systems in the NZE Scenario, 2030



Declining costs of solar PV, wind and electrolysers will bring down the cost of hydrogen, creating export opportunities for countries with good renewable resources

Hydrogen trade can kick start soon, but barriers remain



Annual exports could reach 12 Mt of hydrogen by 2030, but off-take agreements are lagging behind. Key challenges remain in regulation, infrastructure, demand creation, value for exporters and trade rules

First steps on regulation and certification of hydrogen

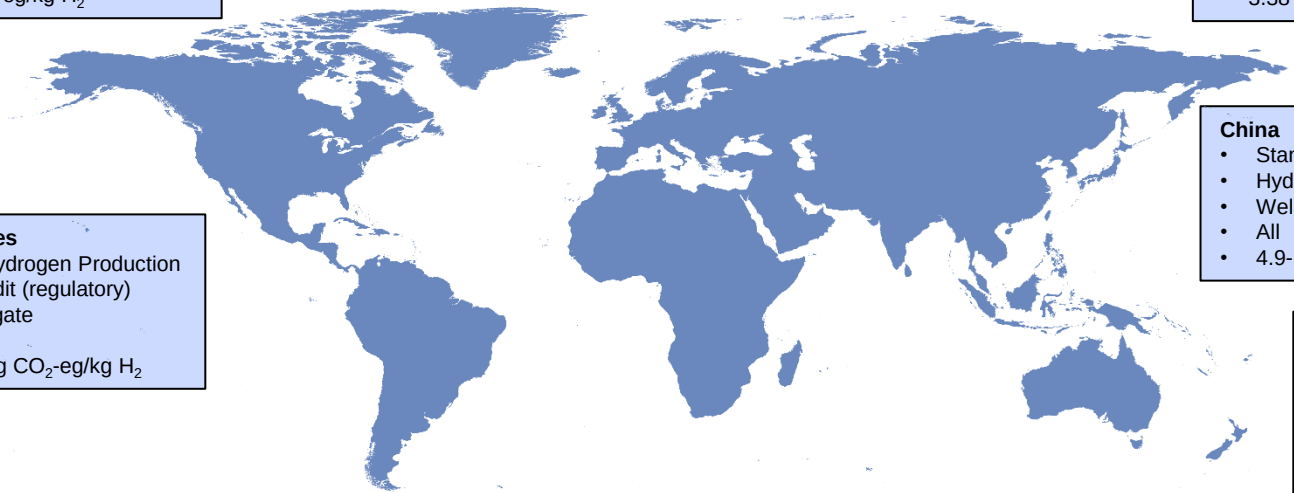
Selected existing and planned certification systems and regulatory frameworks for hydrogen and hydrogen-based fuels

Canada
- Clean Hydrogen Investment Tax Credit (regulatory)
- Well-to-gate
- Electrolysis, natural gas with CCUS
- 0.75-4 kg CO_2-eg/kg H_2

United Kingdom
- Low Carbon Hydrogen Standard (regulatory)
- Well-to-gate
- Electrolysis, natural gas with CCS, biomass and waste
- 2.4 kg CO_2-eg/kg H_2

European Union
- RED II (regulatory)
- Well-to-wheel
- Renewable hydrogen
- 3.4 kg CO_2-eg/kg H_2

France
- Ordinance No. 2021-167 (regulatory)
- Well-to-gate incl. manufacturing
- All
- 3.38 kg CO_2-eg/kg H_2



China
- Standard of China
- Hydrogen Alliance) (voluntary)
- Well-to-gate
- All
- 4.9-14.5 kg CO_2-eg/kg H_2

United States
- Clean Hydrogen Production Tax Credit (regulatory)
- Well-to-gate
- All
- 0.45-4 kg CO_2-eg/kg H_2

Australia
- Guarantee of Origin certificate scheme (voluntary)
- Well-to-gate
- Renewable electricity
-

Using emissions intensity of hydrogen production, based on an agreed methodology, in regulation and certification can enable certain interoperability and minimise market fragmentation

Considerations to strengthen international collaboration on hydrogen

Policy considerations

- **Move from announcements to policy implementation** by reducing risks and improving economic feasibility of projects
- **Raise ambitions for demand creation in key applications** through instruments as auctions, mandates or public procurement and for emerging technologies through innovation and demonstration efforts
- **Intensify international cooperation for hydrogen trade**, with harmonised standards and certification systems being a key enabler
- **Accelerate the development of hydrogen infrastructure**, a critical element for long-distance transport and international trade of hydrogen

Work areas to support low-emission hydrogen by the IEA and CEM Hydrogen Initiative

- IEA report on standards and certification of hydrogen for Japan's G7 presidency
- International Hydrogen Trade Forum being established by CEM Hydrogen Initiative
- IEA work on innovation and clean technology supply chains (e.g. Clean Energy Technology Guide, Energy Technology Perspectives)