SCALING HYDROGEN FINANCING FOR DEVELOPMENT

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Hydrogen Lead
AEA, Atlanta
13 November 2023

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WBG hydrogen: country lending ops led by IBRD-IDA are ramping up

CHILE PROJECT → **$150M Approved IPF FY23** → **Blended finance for electrolyzer CAPEX and risk mitigation instruments**

INDIA PROJECT → **$1.5B Approved DPL FY23 (phase 1)** **$1.5B for approval FY23 (phase 2)** → **Policy support** Offtake Equipment manufacturing RE power access

MAURITANIA PROJECT → **IPF (for approval FY24)** → **Blended finance and capacity building**

BRAZIL PROJECT → **IPF (for approval FY24)** → **Blended finance and infrastructure**

Interest to replicate facility in Colombia and Brazil

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World Bank
in cooperation with:

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OECD

OECD
BETTER POLICIES FOR BETTER LIVES

Global Infrastructure Facility

Global Infrastructure Facility
A G20 INITIATIVE

Hydrogen Council

Hydrogen Council

In support of Breakthrough Agenda and COP28

Extensive support from and consultation with MDBs, governments, investors, financing institutions, H4D partners, and stakeholders

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World Bank Group Hydrogen activities

World Bank Group – 189 member countries

Public sector support
for developing countries

IBRD, IDA

Technical assistance
Concessional financing
Grants
Risk mitigation instruments

Private sector support
in developing countries

IFC

Upstream Project Support
Project Financing
Grants
Concessional Financing

Private sector support

MIGA

Political risk insurance
Credit enhancement
Trade finance

Advice

Advice

Hydrogen for Development Partnership

WORLD BANK GROUP
THE WORLD BANK IBRD • IDA | IFC International Finance Corporation | MIGA Multilateral Investment Guarantee Agency

FLAGSHIP PUBLICATION LAUNCH COMING FRIDAY 17 NOVEMBER

Strategic guidance for World Bank Group hydrogen activities

- The role of financing
- Action agenda

Full report at COP

Followed by a technical briefing on hydrogen for the World Bank Board

Scaling Hydrogen Financing for Development

Analysis structure

1. What is the expected size of the industry?
   Scenarios, projections, business models, projects
2. What is the magnitude of the cost gap? Economic analysis:
   investment needs, financing needs, subsidy needs
3. What are the risks hindering financing and mitigation
   instruments to overcome them?
4. What to do ?
   Implications for policy makers and DFIs
5. Recommendations for COP28
   and decision makers

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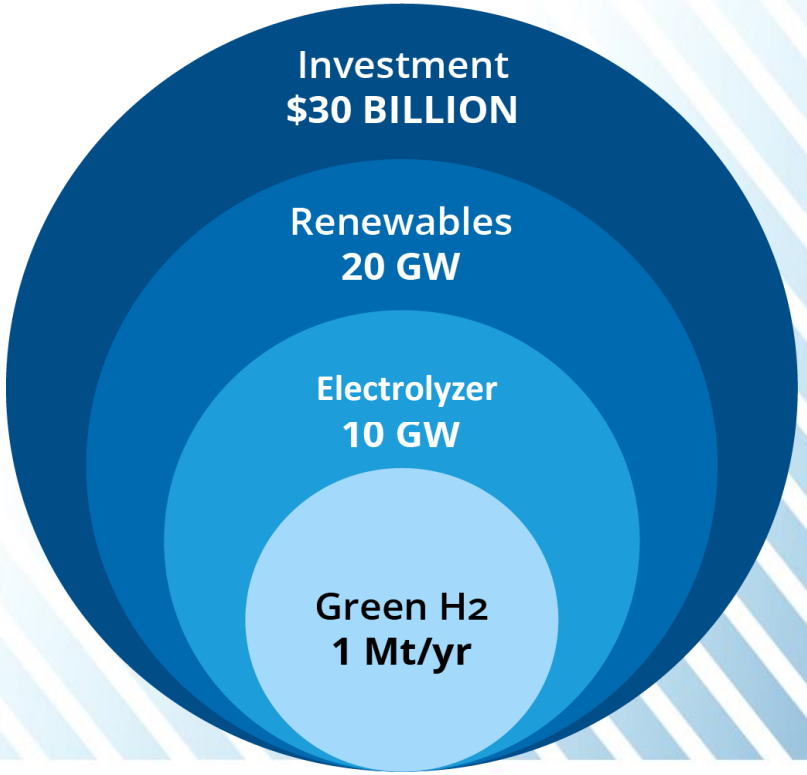
A VERY CAPITAL INTENSIVE INDUSTRY

1 → 10 → 20 → 30

- Target **40 Mt clean hydrogen by 2030**
  US$2 trln investment
  - 20 Mt in EMDC – 100 NEOM-size projects – financing gap 10-40 bln/yr
- Expectation is **1/3 blue & 2/3 green hydrogen in 2030 and 2050**: 80% of production investment needs for green, 20% for blue
- **Bulkiness of commercial scale projects** is an issue
- **Rising interest rates and rising electrolyzer prices** make renewable hydrogen projects more difficult



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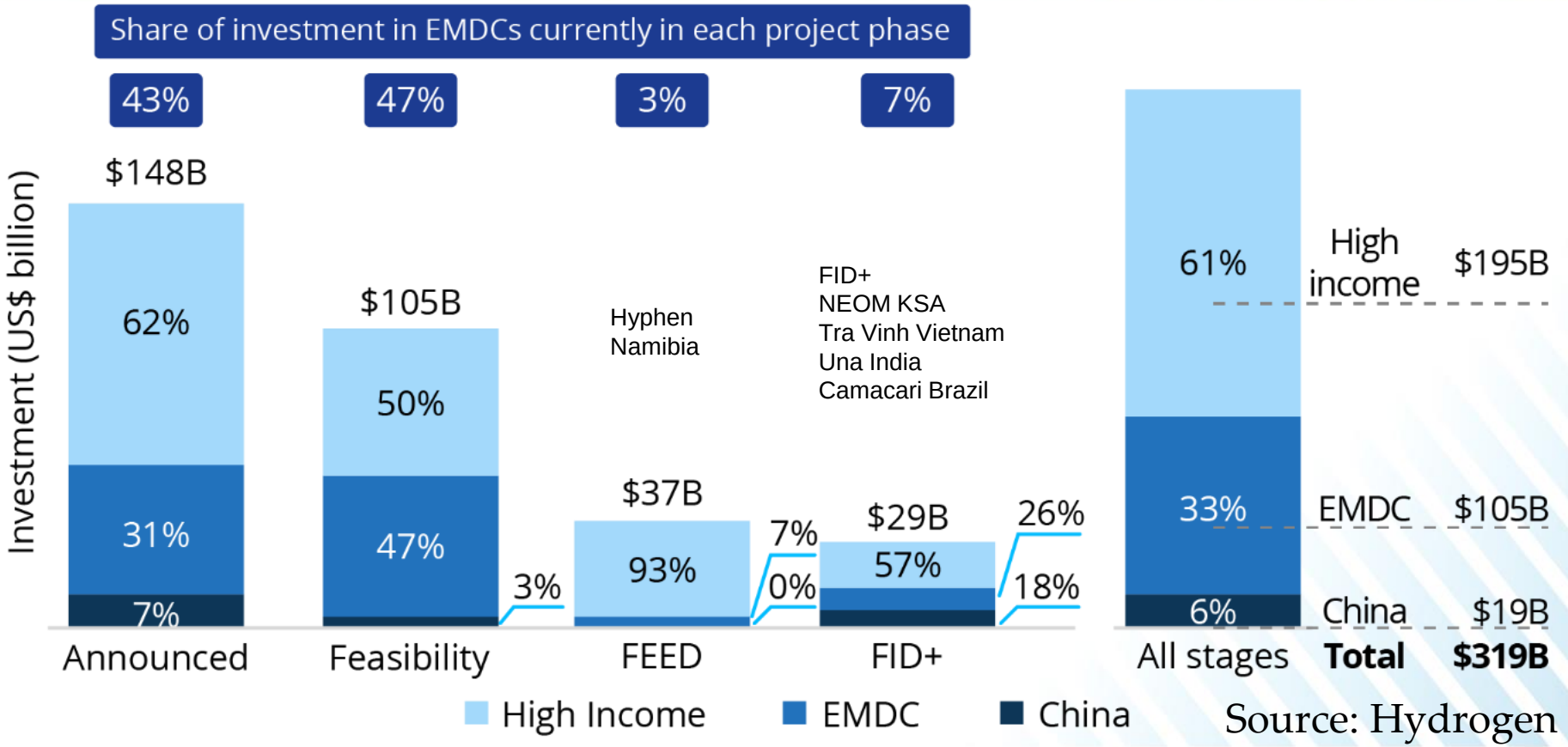
HYDROGEN PROJECTS IN EMDCS ARE LAGGING PLENTY OF ANNOUNCEMENTS, FEW PROJECTS MOVING AHEAD



EMDC: Emerging Markers and Developing Countries

FEED: Front-End Engineering Design

FID+: Final Investment Decision

Note: excludes renewable power component ~ $1 trln when this is included – double again for 1.5 C

Source: Hydrogen Council and McKinsey

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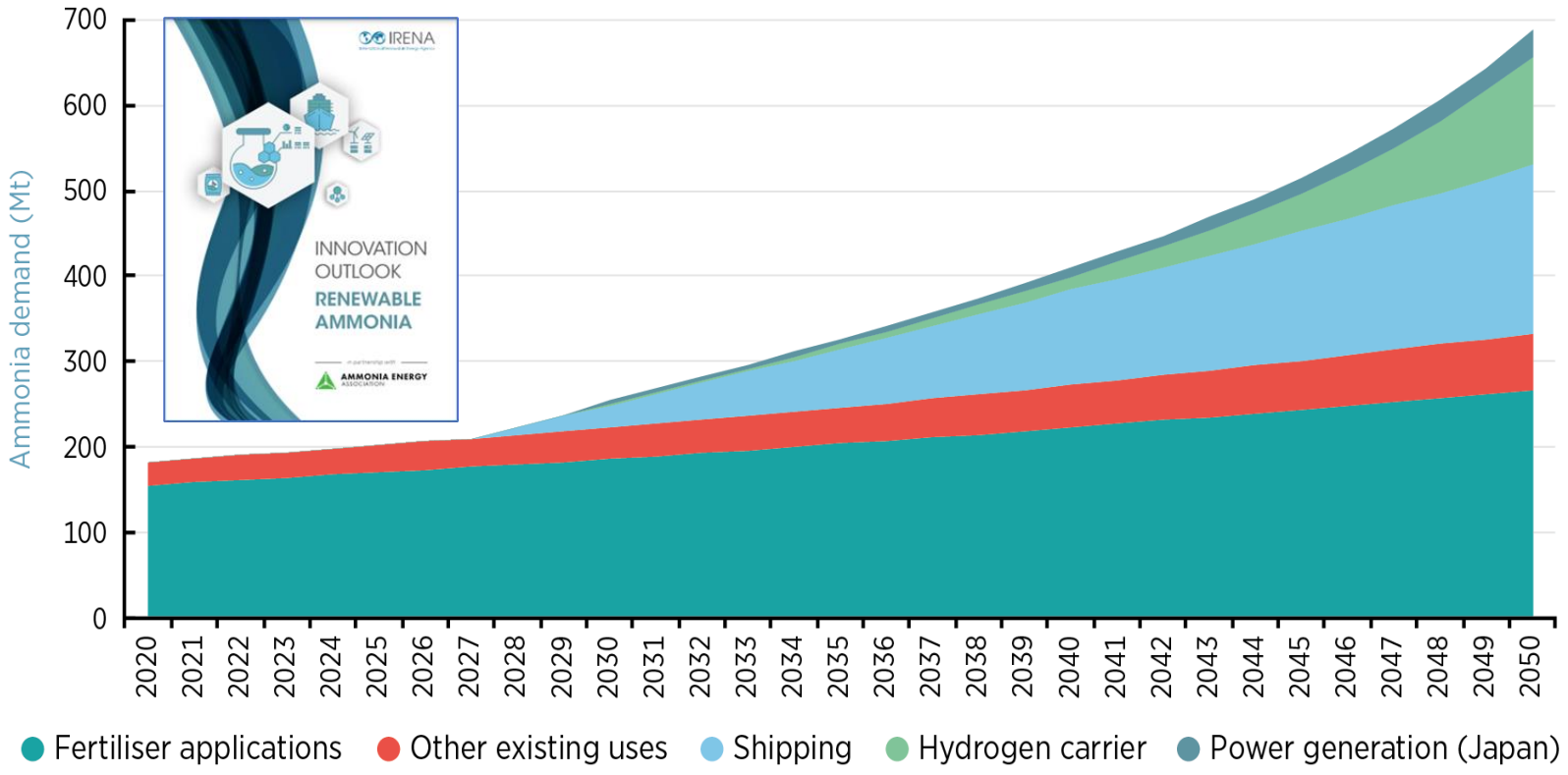
AMMONIA MARKET STATUS AND PROSPECTS – DEMAND SIDE

Expected ammonia demand up to 2050 for the 1.5°C scenario

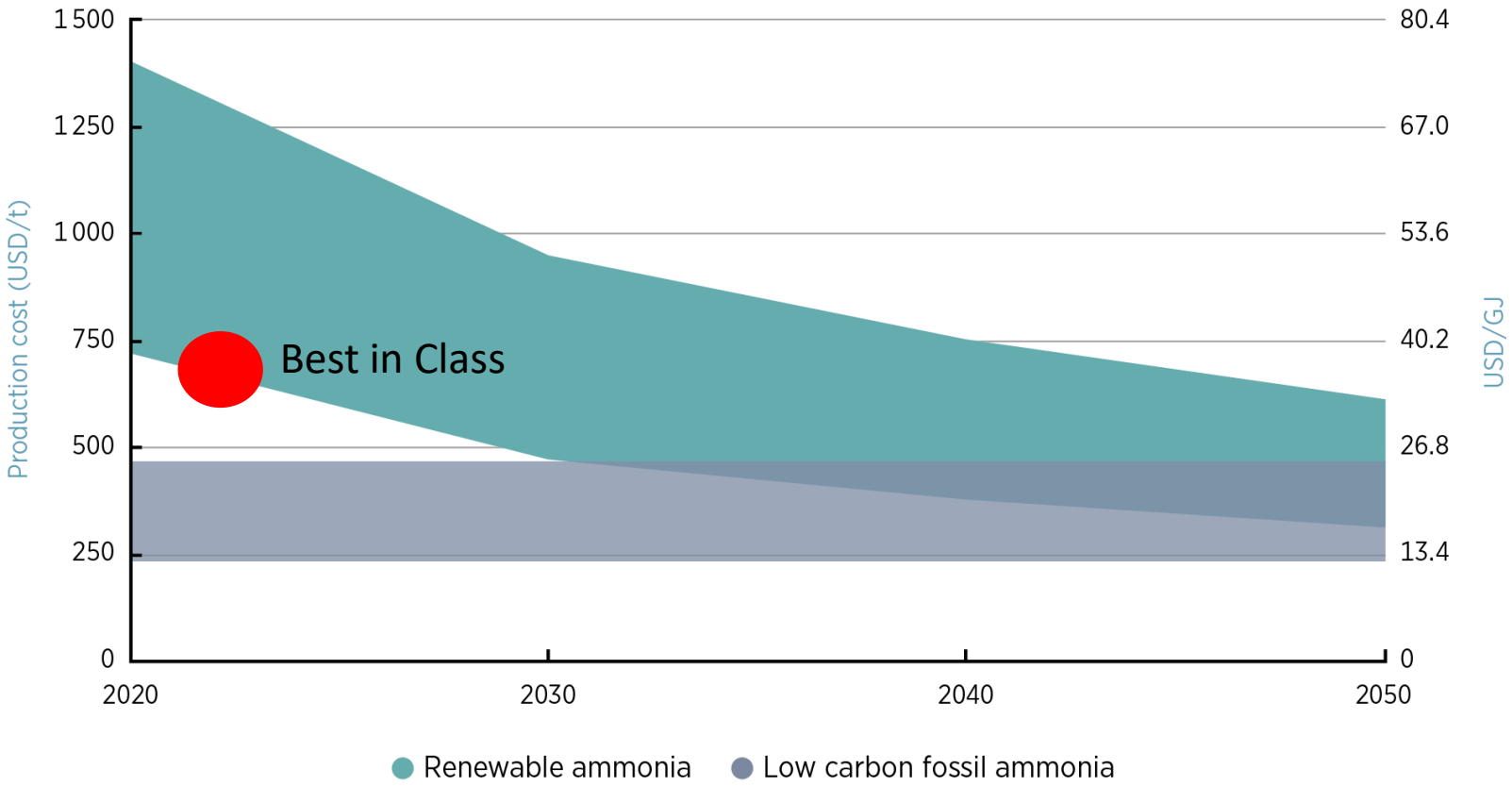


Source: IRENA and AEA, 2022

- Green ammonia to replace current ammonia demand
- Future possible green ammonia applications as shipping fuel, hydrogen carrier and power generation
- 269 Mt under development worldwide.
- 133 Mt clean ammonia projects are under development in EMDCs (ex China)
- EMDC 112 projects (around half of all projects under development worldwide) have an average size of more than 1 Mt
- 1.4 Mt is under construction (1%)

PRODUCTION COSTS - BY 2050 COSTS EXPECTED TO FALL TO USD 310-610/T

Current and future production costs of renewable ammonia



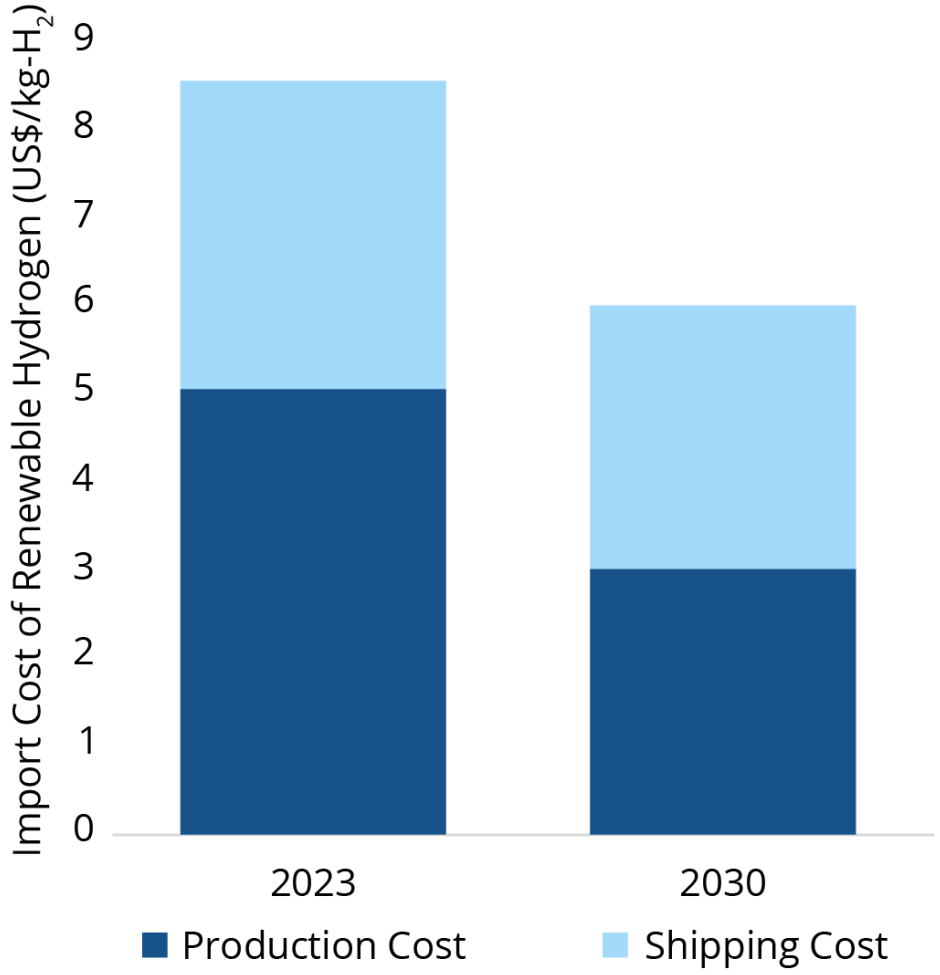
Source: IRENA and AEA, 2022

- Ammonia spot price peaked in 2022, back to normal since
- Green ammonia production cost in good locations are lower than spot prices
- Hydrogen cost dominate renewable ammonia production cost (nearly 200 kg hydrogen/t ammonia)
- Many estimates but no public prices for green hydrogen or renewable ammonia at this moment – H2Global and European Hydrogen Bank will create some clarity through auctions

MARKETS AND PROJECTS

- Most advanced hydrogen projects are ammonia projects
- Ammonia for power – Japan and Korea – possibly 5 Mt by 2030
- Shipping
  - 90 ammonia-ready vessels (Clarkson data Jan 2023), 2 dual-fuel vessels (Exmar), CMB/Bocimar orders etc
  - DNV database 2 vessels + 1 tug boat on order
  - WinGD engineering, Warsila, MAN engine & systems design
- Nitrogen fertilizer prices vary widely
  - Early opportunities where prices are high and import dependency is high
  - CBAM – 100 USD/t CO2 translates into 150 USD/t ammonia more expensive grey
- Ammonia as hydrogen carrier – but cracking is relatively inefficient and therefore costly

Shipping cost matter
Infrastructure warrants attention from an economic and enabling perspective



Source: Scaling Hydrogen Financing for Development, forthcoming

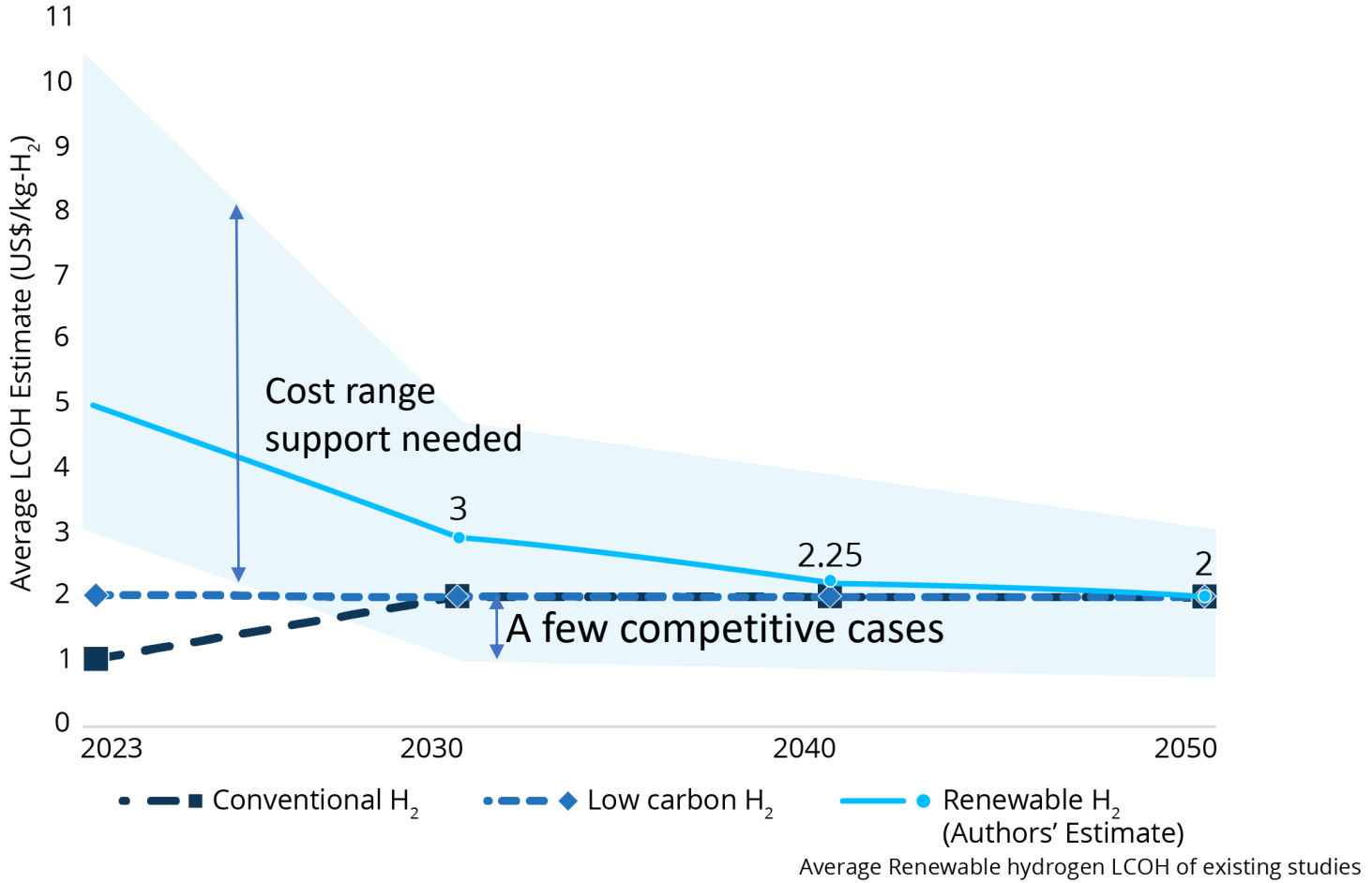
Ammonia is today the only large scale affordable hydrogen shipping option

As long as its used as ammonia (fertilizer, shipping fuel, power)

Cracking efficiency today 70% - need for innovation

Important WB activities related to ammonia infrastructure

Green hydrogen production will only become cost effective through robust innovation, deployment support and carbon pricing and carbon financing



Source: Scaling Hydrogen Financing for Development, forthcoming. Compiled range of estimates for different types of hydrogen based on 26 global studies published after 2021.

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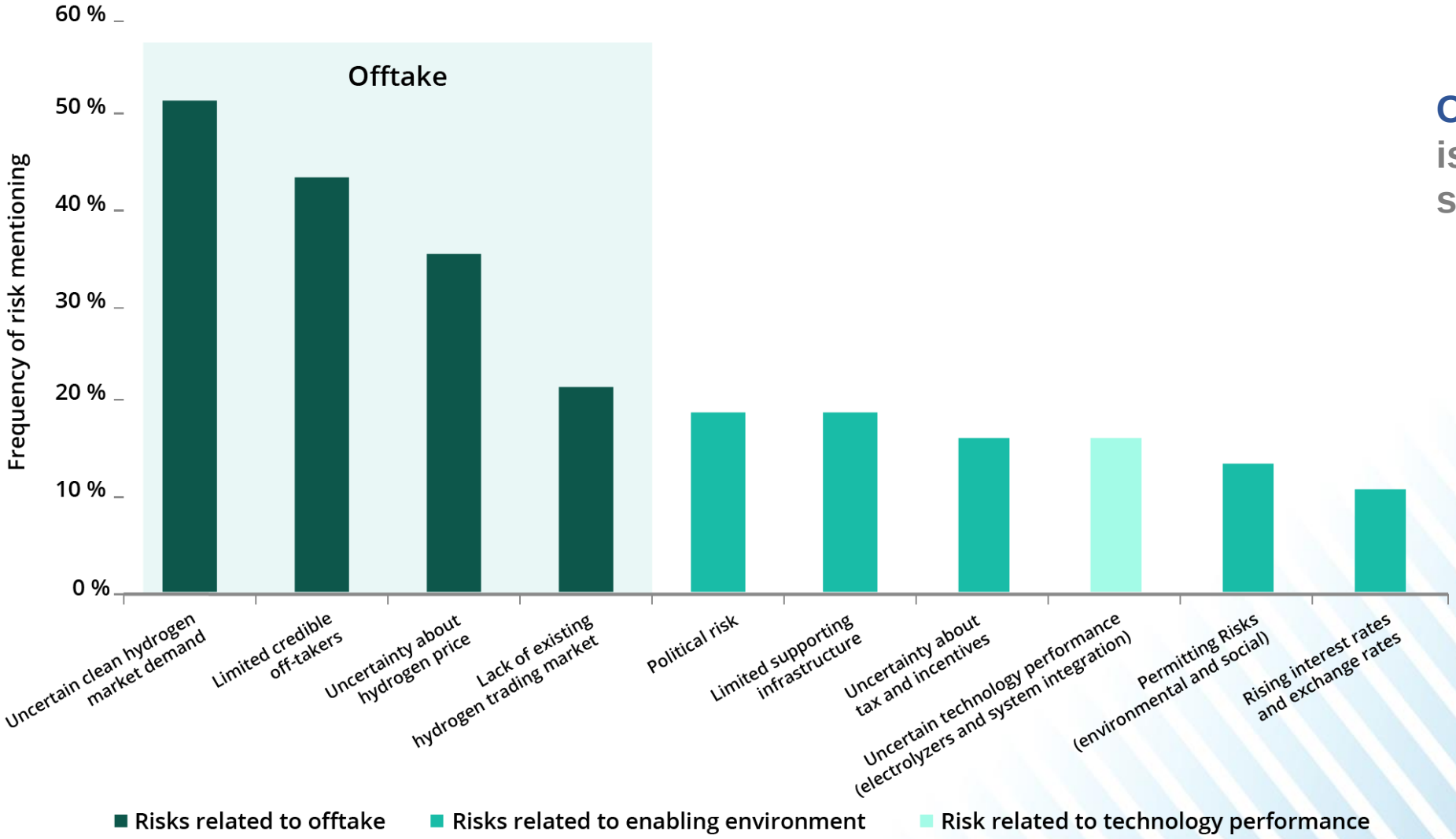

Offtake risk
is the most critical sub-category of risk

Source: Scaling Hydrogen Financing for Development, forthcoming

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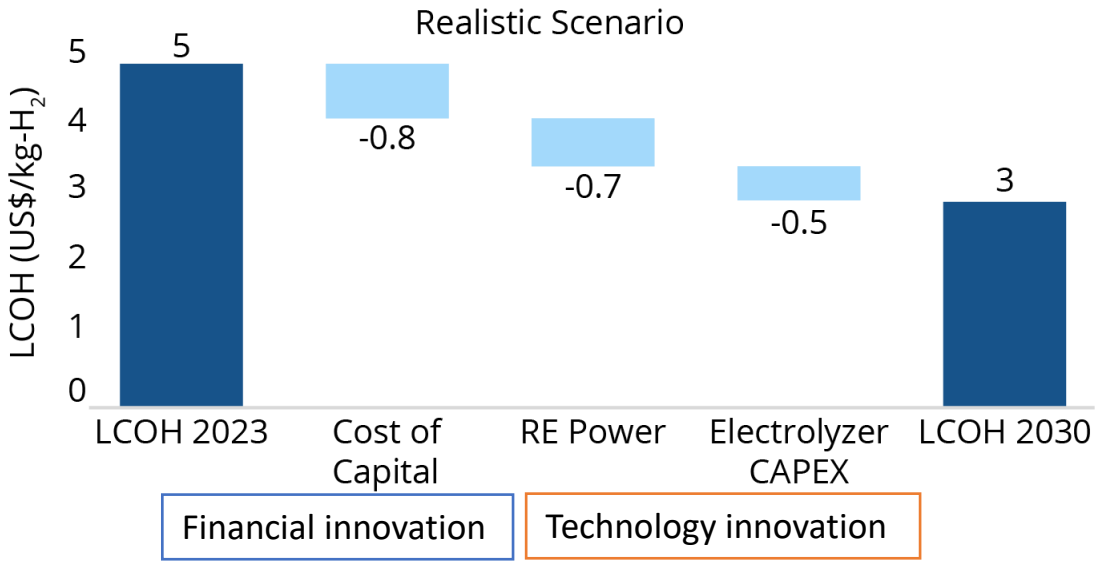
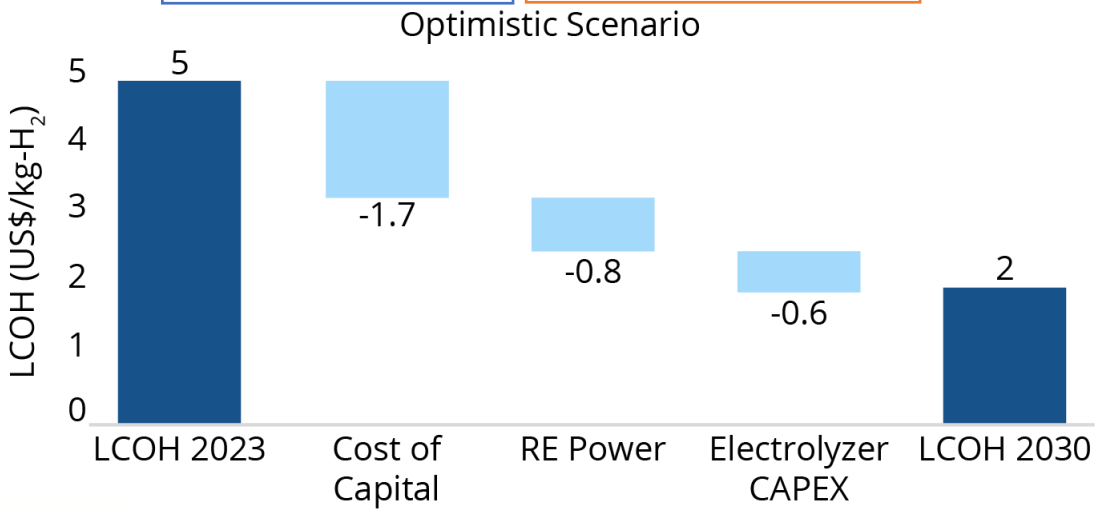
OFFTAKE RISK

- Synonymous with “this stuff is more expensive, who will pay the premium”
- Offtake contracts specify price, duration, volume
- Delivery location and quality
- Generally offtake contact is shorter than the project life (NEOM exception)
- An MoU or a press release is not the same as an offtake contract
- Chicken or egg problems:
  - Who signs a long term contact when prices are expected to fall
  - Not project, no contract. No contract, no project.
- Possible solutions: regulated users, first movers (eg in shipping), carbon pricing, government support

Reduction in production cost of renewable hydrogen, 2023 to 2030 – the importance of financing cost

For the reduction to happen, early mover projects need to happen, without which expertise and implementation cannot evolve



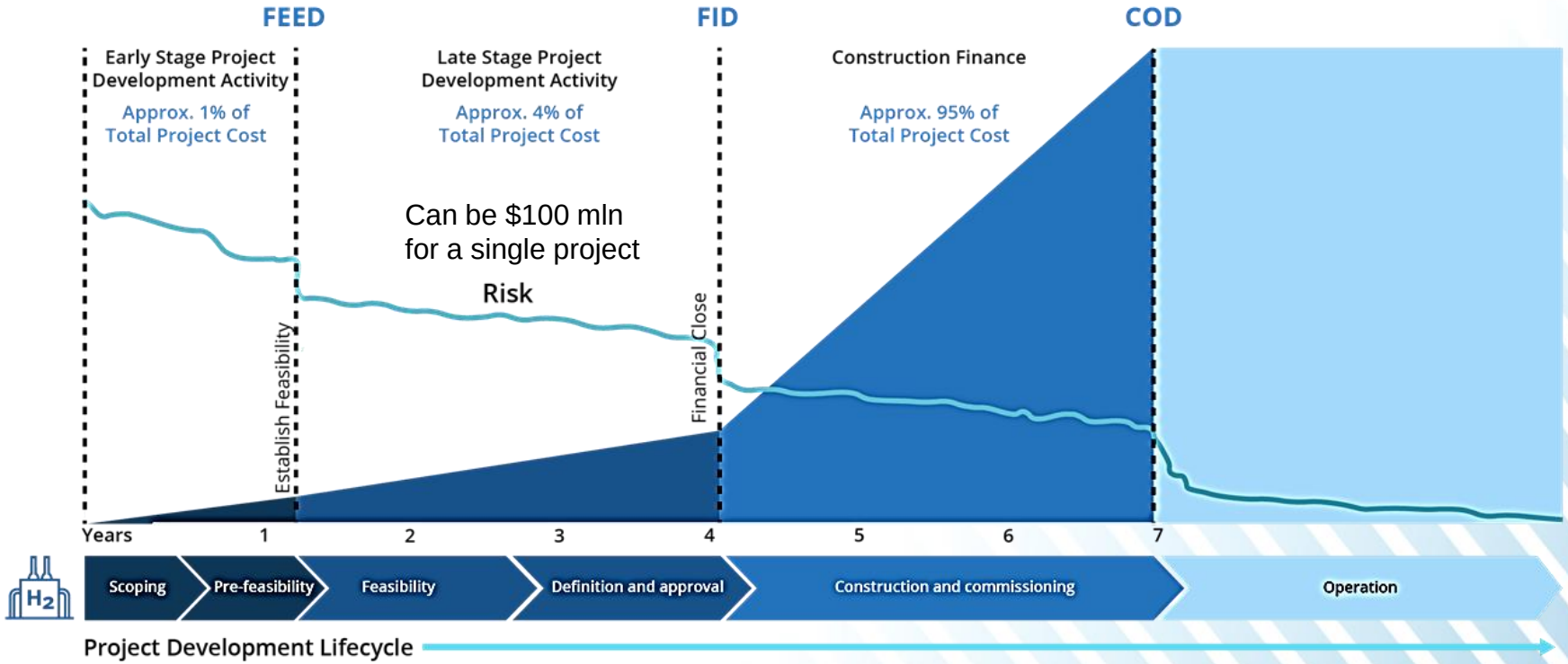


Source: Scaling Hydrogen Financing for Development, forthcoming

NEED TO DEVELOP SPECIFIC RISK MITIGATION INSTRUMENTS IN ORDER TO REDUCE FINANCING COST

Pre-FID:
Offtake, infrastructure, license to operate risk

Post FID:
Policy risk, creditworthiness risk, technology risk, etc.



FEED: Front End Engineering and Design; **FID**: Final Investment Decision; **COD:** Commercial Operation Date

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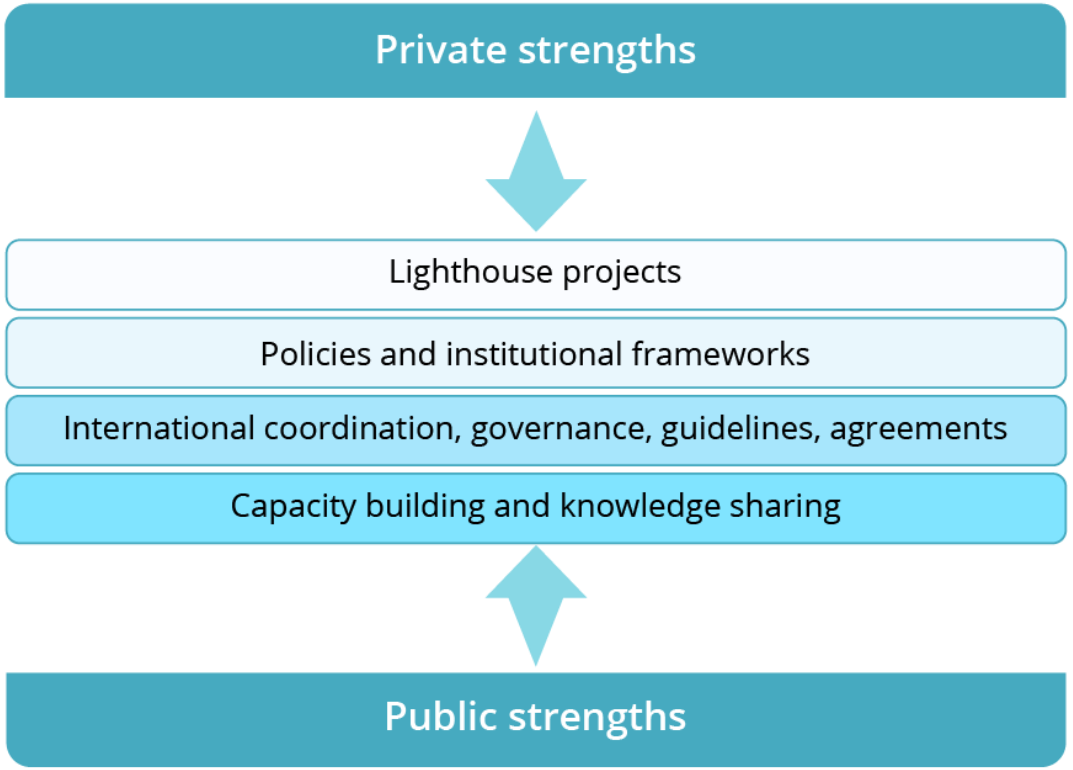
RECOMMENDED POLICY ACTIONS



10 GW lighthouse initiative under discussion

- Create confidence and reduce financing cost
- Debottleneck EMDC project pipeline
- Get projects to FID
- Mid-size or phased projects

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Ideas in action:
Hydrogen for Development (H4D Partnership members)

Provide **technical assistance** and **practical guidance** to deploy clean hydrogen projects in developing countries and emerging economies

- ESMAP-led initiative established at COP27
- Has grown from 12 to 36 members
- Provides best practice advice to WBG member countries
- Meeting to share lessons learned in India (March 2023) and Chile (October 2023)

H4D Partnership

AEA to join soon !

AGHA The Africa Green Hydrogen Alliance
ADECE
RMI
Australian Hydrogen Council
CCEE
Centre for Hydrogen Energy Systems Sweden - CH2ESS
H2Chile Asociación Chilena de Hidrógeno
Consorcio H2ar
CORFO
Dii
FCHEA Fuel Cell & Hydrogen Energy Association
Freeport Saldanha Industrial Development Zone
IFC
Green Hydrogen Catapult
GH2 Green Hydrogen Organisation
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
hidrogeno Colombia
H2 México Asociación Mexicana de Hidrógeno
Ministry of Energy and Mineral Resources of Jordan
H2 lac
ESMAP Energy Sector Management Assistance Program
Hydrogen Council
Hydrogen Europe
Hydrogen Egypt
Hydrogen Task force by MEDEF International & France Hydrogène
H2KOREA
IH2A India Hydrogen Alliance
Japan Hydrogen Association
JBIC Japan Bank for International Cooperation
NREL
OECD
Pecém Complexo Industrial e Portuário
PDASL
Rijksdienst voor Ondernemend Nederland
RISE Research Institutes of Sweden
Western Cape Government

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STANDARDS AND CERTIFICATION SYSTEMS FOR LOW CARBON AND RENEWABLE HYDROGEN AND AMMONIA

DOLF GIELEN, HYDROGEN LEAD

AEA ATLANTA, NOVEMBER 13, 2023

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NEED TO THINK IN SUPPLY CHAINS AND BUILD ON EXISTING STANDARDS & CERTIFICATION SYSTEMS

- I-REC (International)
- REC (North America)
- AIB (EU) Association of Issuing Bodies

Renewable power → Hydrogen → Ammonia

Methodological issues for grid power:

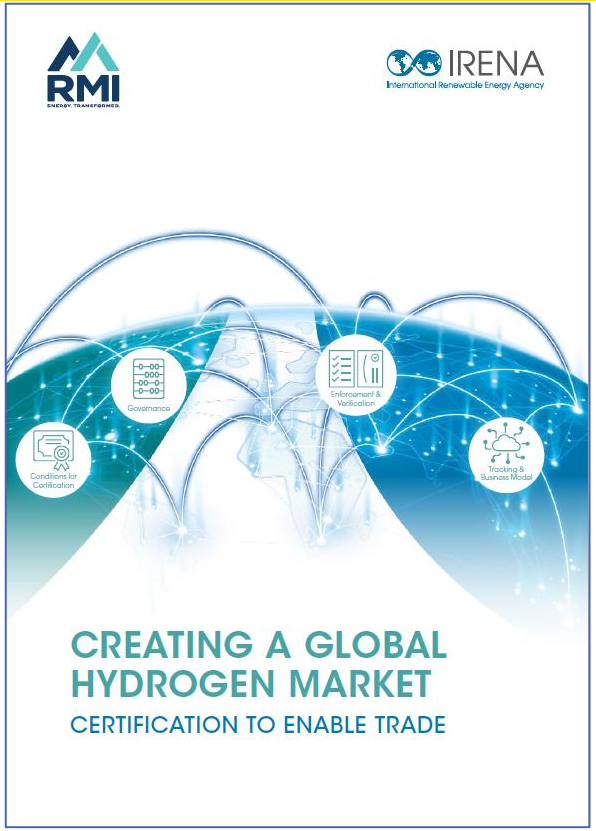
Stand alone vs grid

Additionality

Temporal & spatial matching

Consistency and coherence required along the supply chain

THE IMPORTANCE OF INTERNATIONAL COOPERATION FOR HYDROGEN, INCLUDING S&C



September 2022

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Hydrogen deployment must be underpinned by **rigorous emission standards**.

Eight voluntary and five mandatory schemes were assessed. The IRENA/RMI report is a contribution to the work on the G7 Hydrogen Action Pact

- None of the existing hydrogen certification systems are suitable for cross-border trade.

G7 pledged in April 2023 to develop a transparent global hydrogen market based on "reliable international standards and certification schemes".

- A rule-based, transparent global market and supply chains
- Based on reliable international standards and certification schemes
- Adhering to environmental and social standards,
- In particular with regard to water use conflict
- Thus promote organic collaboration between supplier and c[illegible]ies to reduce costs.

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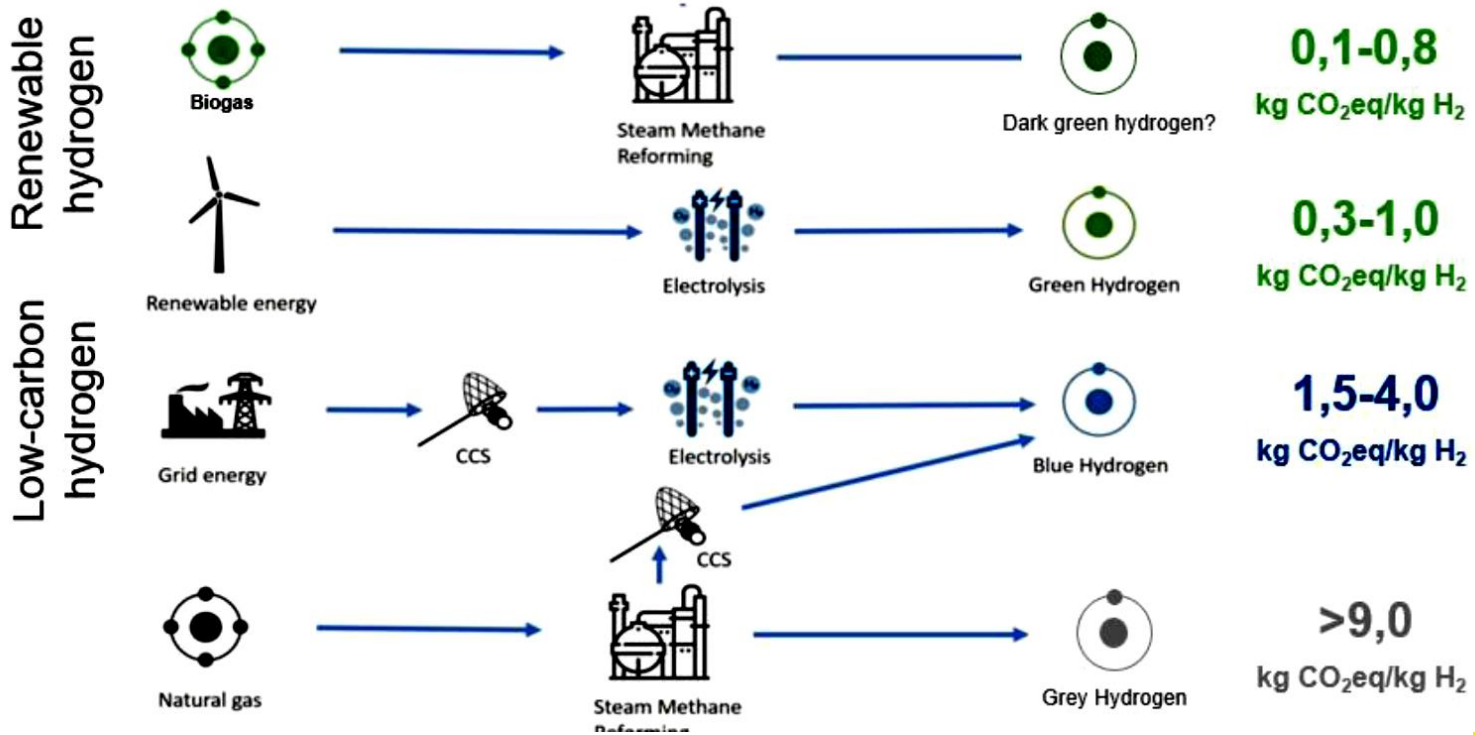
RECOMMENDATIONS

- A modular approach to certification at different stages along the supply chain
- A single methodology to calculate the emissions intensity of all H2 production pathways
- Alignment between accounting methods and policy requirements for additionality, temporal and geographical criteria for hydrogen produced using grid electricity;
- Internationally accepted methodologies to manage blending of traded hydrogen in order to link production criteria with market requirements;
- Harmonised systems of quality infrastructure for national standards bodies to ensure fairness and accountability of hydrogen certification;
- Establish a process to facilitate mutual recognition between certification schemes for hydrogen and derivatives; and
- Think beyond hydrogen and ensure continuity for the hydrogen derivatives most likely to be traded, such as ammonia.

GREEN AND BLUE HYDROGEN CAN YIELD SIGNIFICANT EMISSION SAVINGS NORWEGIAN CASE – LOW UPSTREAM METHANE EMISSIONS!

- **EU taxonomy** <3 kg CO_2 eq/kg is "sustainable"
- **US tax credits** start at 6 kg CO_2 eq/kg, reach their maximum at 0.45 kg CO_2 eq/kg
- **Low carbon/blue emission factor** depends on methane leakage and GWP time horizon
  - 3% leakage (typical US shale gas) and 84 relative GWP (20 years) yields additional (.03x84x3) = 7.6 kg CO_2 eq/kg H_2

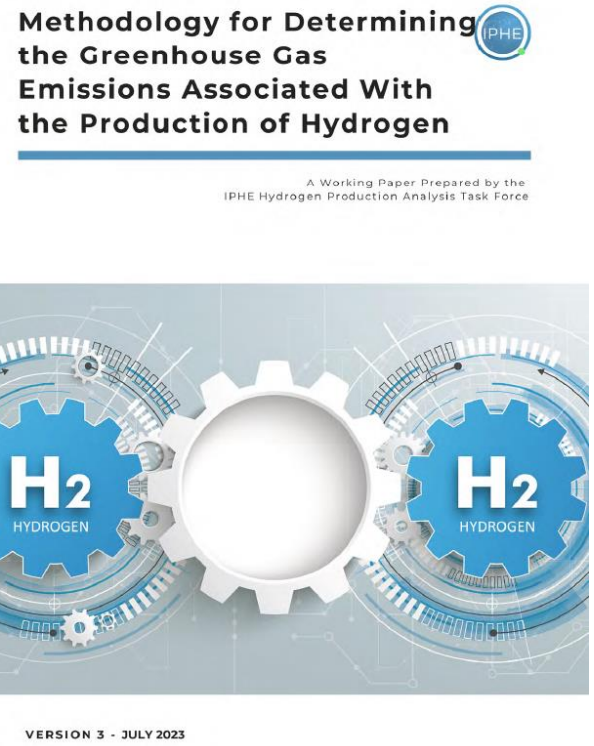


Source: DNV, 2022

IPHE Task Force on Hydrogen Production Analysis

'*Quantification* Methodology' Working Paper Version 3

- Published *Methodology for Determining the GHG Emissions Associated with the Production of Hydrogen Working Paper* Version 3 July 2023



- **Hydrogen Production Pathways:**
  - Electrolysis
  - Steam Methane Reforming with CCS
  - Industrial By-Product
  - Coal Gasification with CCS
  - Biomass
  - Auto-Thermal Reforming with CCS
- **Conditioning and Carriers of H_2**
  - Liquefaction
  - Ammonia
  - Liquid Organic Hydrogen Carriers
- **Transportation of H_2**
  - Marine; Pipeline; Mobility – Train, Truck

→ **transferred to ISO TC197/SC1/WG1**

→ **ISO TS 19870 expected for COP28**

→ **Close of voting 14 November**

MULTIPLE EFFORTS ARE ALREADY ONGOING IN THE AREA OF HYDROGEN STANDARDS AND CERTIFICATION

Hydrogen

Body	Reference	Threshold
AFHYPAC	None	100% renewable
CertifHy	Grey hydrogen	60% lower GHG
TUV SUD	Grey hydrogen	35-75% lower GHG
Clean Energy Partnership	Grey hydrogen	100% renewable
REDII	Transport fuels	70% reduction
TEG Sustainable Finance	None	5.8 tCO2/tH2 or 100 gCO2/kWh for input

- EU. (1) CertifHy is starting a Phase III; (2) Gas GO system; (3) Engaging with Chile and Morocco
  - WorldBank analytical work for Chile: https://hinicio.com/wp-content/uploads/2022/08/Hinicio_green_hydrogen_certification_report_Chile_WB.pdf
- Australia. Certification trials and methodologies

RECENT DEVELOPMENTS AND ONGOING EFFORTS IN RELATION TO HYDROGEN STANDARDS AND CERTIFICATION

- IPHE - methodology issued Dec 2021, next trade rules WG, ISO liaison
  - Announcement to support mutual recognition of certification schemes at COP28 (5 December 2023)
- Hydrogen Council, IPHE, IEA TCP, IRENA Breakthrough 101 report
- Renew Energy Directive (REDII)
  - 13 voluntary schemes adopted – need to re-apply for RFNBO
- EU CertifHy registry
- ERGAR European Renewable Gases Registry (so far mainly biogas)
- DENA-WEC Report Global Harmonisation of Hydrogen Certification
- Other national certification system developments, such as:
  - Mallorca GreenH2Chain platform; Australia H2GO; UK RGGO

INSIGHTS FROM THE INVENTORY OF EXISTING S&C SYSTEMS

- Need portfolio of **internationally-recognized standards** and **certification boundaries and thresholds**
- International **harmonization** in methodology and **boundary** required.
  - **Wording:** clean, renewable, green, low carbon
  - Varied criteria for **emissions threshold** ranging between 1.0kg CO_2e/kg H_2 ("green hydrogen") and 4.9 kg CO_2e/kg H_2 ("clean/low carbon").
  - Inconsistent **emissions reporting boundaries** between schemes, ending at either H_2 point of use or point of production - direct comparison not possible.
  - ~1/3 of existing and emerging certification schemes require RE **"additionality"**
- National policy needs to provide **guidance on RE criteria** (RE carbon accounting, transfer of renew electricity GOs to H_2 producers and end consumers)

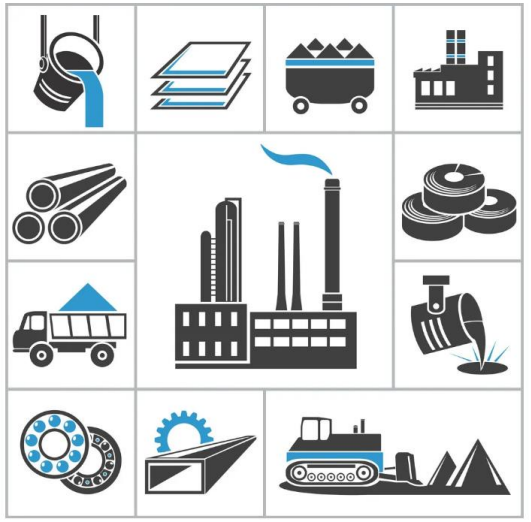
SETTING STANDARDS AS POLITICAL PROCESS : EUROPEAN RED II

- First delegated act – definition and production of renewable hydrogen (part of RFNBO)
  - Also applies to imports (hydrogen and ammonia) etc
  - Imports count towards meeting European renewables targets

- EU Commission DRAFT May 2022 – renewable hydrogen.
  - **Additionality of RE power** – no state aid, 36 month rule
  - Called for same calendar month **RE balancing**, hourly balancing from 2030
  - Individual member states can still decide to apply **more strict standards**
  - CerifHy to inform national systems design

European Carbon Border Adjustment Mechanism (CBAM)
Carbon pricing for traded commodities

- Goal: **fair competition** own and foreign producers of energy intensive commodities
  - Same accounting issues as for standards & certification systems
- EU **ETS** – same carbon price for imports
- Applies to **Aluminum, Cement, Fertilizer (including ammonia), Hydrogen, Steel, Electricity**
- Starts soon but **first years only accounting**, no pricing
  - Ramping up to full pricing between 2026 and 2034



GHG standards do not pose an immediate problem to develop clean and renewable ammonia

Most renewable ammonia export projects under development use dedicated RE power, not grid connected

Such projects will meet all GHG standards

However need for certification in order to ensure "clean" nature of the produce to warrant a premium price

Blue ammonia projects more susceptible to scrutiny

The use of CO2 matters – length of storage is contentious

Methane upstream emissions can be contentious

Lax standards for blue ammonia can impact the viability of renewable ammonia

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CERTIFICATION SYSTEM ELEMENTS

	Certification Design and Standard	Governance	Enforcement	Tracking & Business Model	Scale Adoption
Required Detail	• Defines scope and boundary • Data Inputs and Quality (measurement type, conversions/calculation, Frequency) • Data handling protocol (IT systems) • Sets threshold or criteria • Defines base unit for certification attribution	Outlines the roles and responsibilities of: • Standard & Certification Owner • Certificate Issuing body and Registry Defines any enforcement mechanism and noncompliance clauses	• Audit and verification based on standard criteria • Awards certification	Chain of Custody mode: • Mass Balance • Book and Claim Digital credit issuing & retirement platform • Registry • Tradability • Credit Value Product Service • Consumer Offering (i.e., emissions reduction)	• Demand Aggregation • Market Engine (normalization to other metrics) • Harmonization to other Standards of Clean H2 • Policy Integration pathway

All elements critical to scale renewable hydrogen as a differentiated product.

Source: IRENA and RMI

ANALYSIS OF HYDROGEN CERTIFICATION – VOLUNTARY MARKETS

Title	Label	Emissions Threshold (kg CO2e/kg H2)	Boundary	Power Supply Requirement for Electrolysis	Hydrogen Production Pathway	Chain of Custody (CoC) Model
Australia Smart Energy Council Zero Carbon Certification Scheme	Renewable H2	No threshold				Unclear
China China Hydrogen Alliance Standard and Assessment for Low-carbon Hydrogen, Clean Hydrogen, and Renewable Hydrogen Energy	Renewable H2	4.9				Not specified
	Clean H2	4.9				Not specified
	Low-carbon H2	14.5		n/a		Not specified
European Union CertifHy Green and Low-Carbon Hydrogen Certification	Green H2	4.4				B&C
	Low-carbon H2	4.4				B&C
Germany TUV SUD CMS 70	Green H2 (non-transport)	2.7				B&C
	Green H2 (transport)	2.8				Mass
Japan Aichi Prefecture Low-Carbon Hydrogen Certification	Low-carbon H2	No threshold				B&C
International Green Hydrogen Organisation Green Hydrogen Standard	Green H2	1.0				Not specified

KEY

Indicates threshold value

Includes upstream methane
To point of production
To point of use

Power Supply Requirements
- GO + Additionality
- GO required
- No GO / additionality specified
- Solar, Wind or Hydro
- Nuclear
- Grid (or unspecified)

Hydrogen Production Pathway Specified
- Electrolysis
- Fossil SMR/ATR with carbon capture
- Biogas SMR

Source: IRENA and RMI

ANALYSIS OF HYDROGEN CERTIFICATION – MANDATORY MARKETS

Country/Region	National Hydrogen Strategy	Boundary and Scope (Sectors)	Emissions Threshold (kgCO2e/kgH2)	Power Supply Requirement for Electrolysis	Hydrogen Production Pathway	Regulatory mechanism	Status of regulatory mechanism
United Kingdom	**Government of the United Kingdom** UK Hydrogen Strategy	(Energy)	2.4	◑ ● ●		**BEIS** UK Low Carbon Hydrogen Standard	To be implemented in 2022 Certification scheme **to be developed by 2025**
		(Transport)	3.9	● ○ ○ ●		**UK Dept. for Transport** Renewable Transport Fuel Obligation (RTFO)	**Active**
European Union (Proposed)	**European Commission** A hydrogen strategy for a climate-neutral Europe	(Transport, Energy)	3.4	● ○ ○ ●		**European Commission** RED II	**Active** New Delegated Act of RED II **proposed in May 2022**
		Boundary not specified	3.0	◑ ● ●		**European Commission** EU Taxonomy	**Active**
United States (Proposed)	*Framework only* (Hydrogen Strategy: Enabling A Low-Carbon Economy). **U.S. Department of Energy** National Clean Hydrogen Strategy and Roadmap *in development*	(Transport, Energy)	2.0	○ ● ●		**U.S. Department of Energy** H2Hub draft *(may be adopted by standard for clean H2 production)*	Draft guidance released; **Still in development**
		(Transport)	No threshold (Certificate issued based on reduction from annual target)	◑ ○ ●		**California Air Resources Board** Low Carbon Fuel Standard (LCFS) - California only	**Active**
KEY	Indicates threshold value	Includes upstream methane To point of production To point of use "Energy" references all non-transport sectors that use hydrogen as a fuel source.		**Power Supply Requirements** GO + Additionality GO required No GO / additionality specified Solar, Wind or Hydro Nuclear Grid (or unspecified)		**Hydrogen Production Pathway Specified** Electrolysis Fossil SMR/ATR with carbon capture Biogas SMR	

Source: IRENA and RMI