

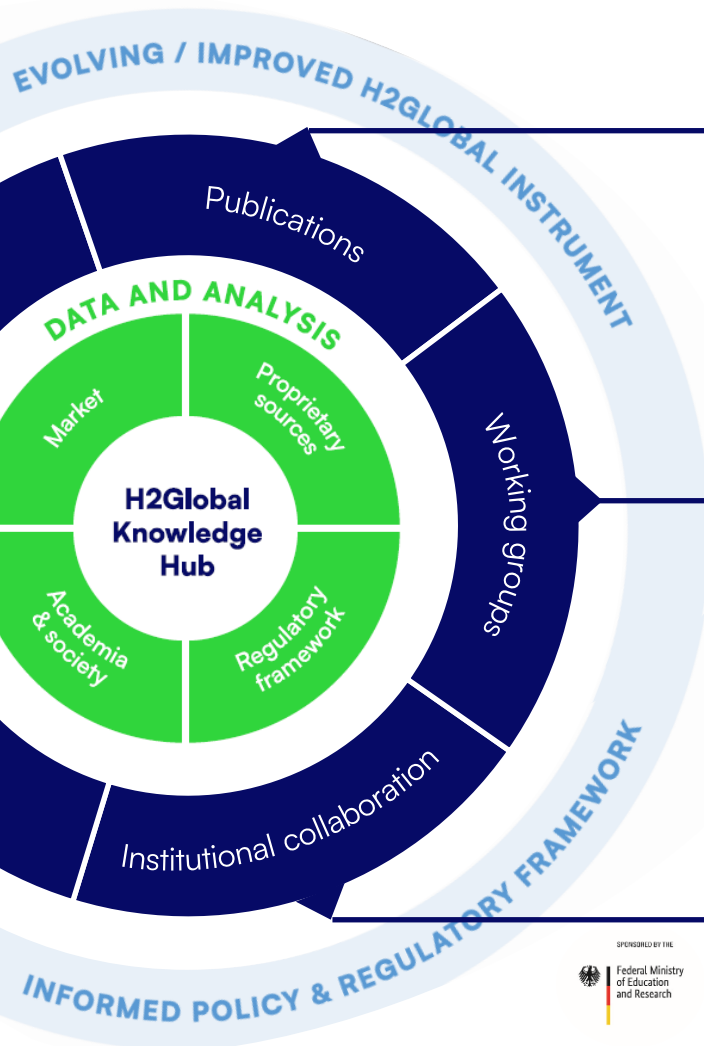


H2Global research reports of 2024

Presentation at Unlocking Clean Hydrogen Markets: A Look at Japan's Support Initiatives and the H2Global Market Maker Instrument

January 2025

The reports are part of the H2Global Knowledge Hub



THREE PUBLICATIONS IN 2024

- Bridging the gap: Mobilizing investments in hydrogen infrastructure
- Unlocking potential: Scaling demand through hydrogen hubs
- Keep it simple: Aligning auction objectives for success

CONTRIBUTION OF INDUSTRY EXPERTS COVERING THE WHOLE HYDROGEN VALUE CHAIN

- Regular virtual knowledge exchanges and in-person workshops
- Representation from finance, supply, infrastructure, demand, and manufacturing

COLLABORATION WITH KNOWLEDGE PARTNERS FROM:

- Center on Global Energy Policies at Columbia University
- IRENA
- OECD
- Oxford Institute for Energy Studies
- World Bank

Agenda

1

Bridging the gap

Mobilizing
investments in
hydrogen
infrastructure

2

Unlocking potential

Scaling demand through
hydrogen hubs

3

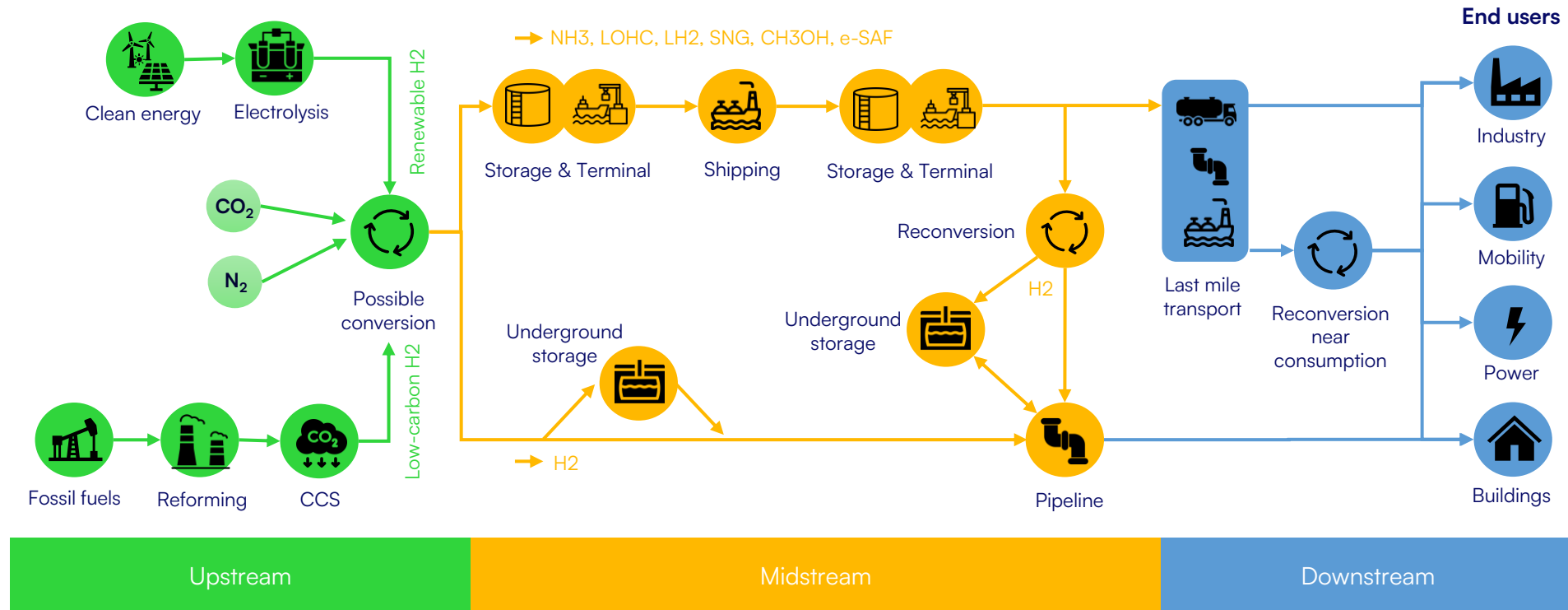
Keep it simple

Aligning auction
objectives for
success



Bridging the gap: Mobilizing investments in hydrogen infrastructure

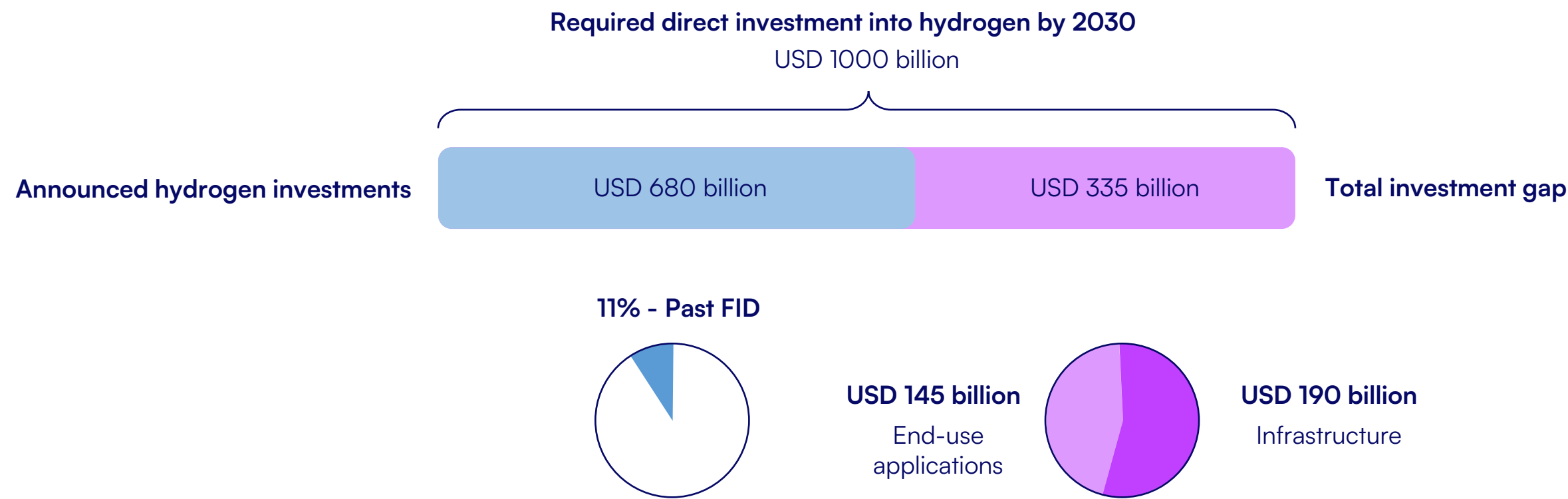
Hydrogen infrastructure is essential for enabling global hydrogen trade



NH₃: Ammonia, LOHC: Liquid organic hydrogen carrier, LH₂: Liquid hydrogen, SNG: synthetic natural gas, CH₃OH: methanol, e-SAF: Synthetic aviation fuel

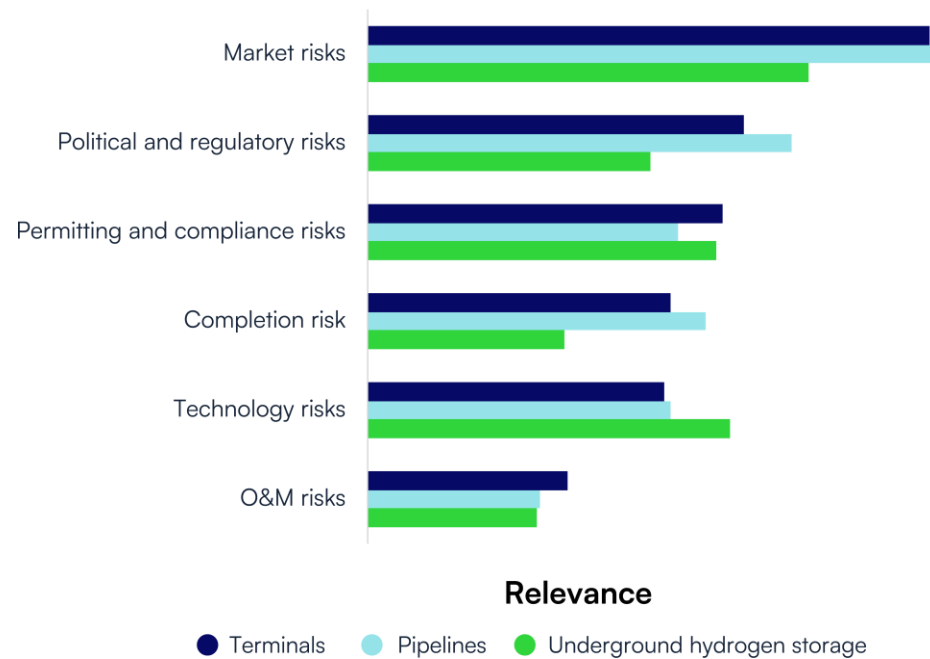
Midstream hydrogen infrastructure—including **pipelines, import terminals, reconversion facilities,** and **underground hydrogen storage**—will be the backbone of a global clean hydrogen trade.

Hydrogen infrastructure faces a major investment gap of USD 190 billion by 2030

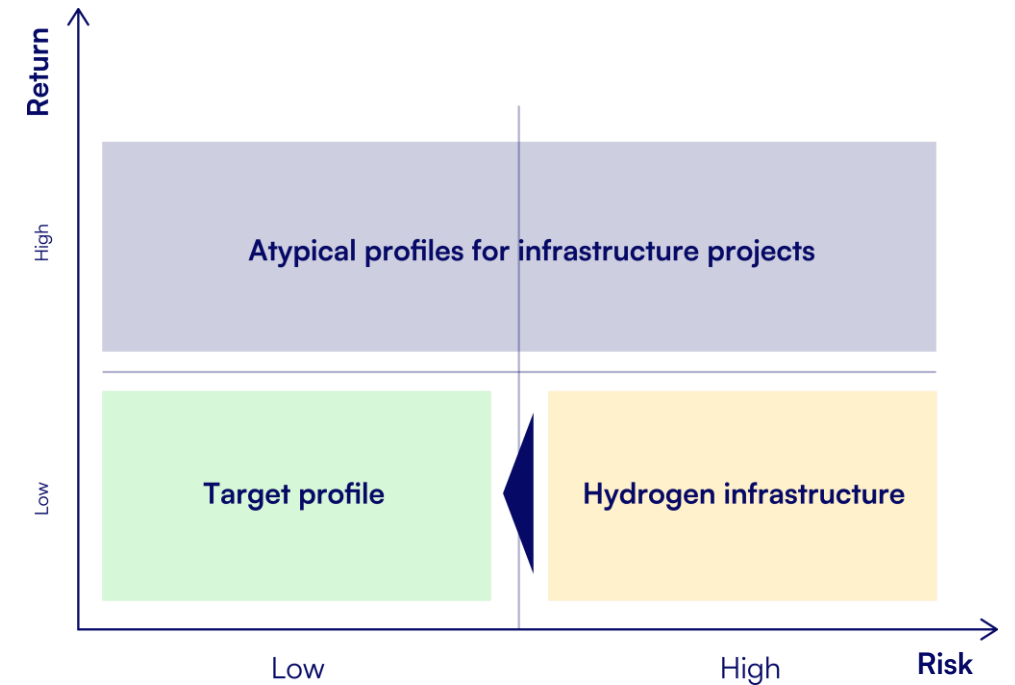


Identification and assessment of infrastructure projects' risk-return ratios

Investment risks



Risk-return ratio



Unfavorable risk-return ratios require financial support instruments to de-risk investments in hydrogen infrastructure.

Four financial support instruments that can help unlock infrastructure investment

Fixed subsidy tools

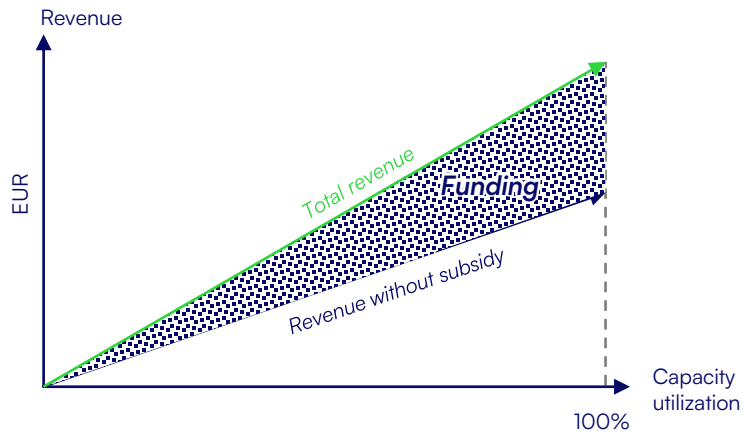
CAPEX support

Upfront one-time payment to reduce initial investment costs.

Dynamic subsidy tools

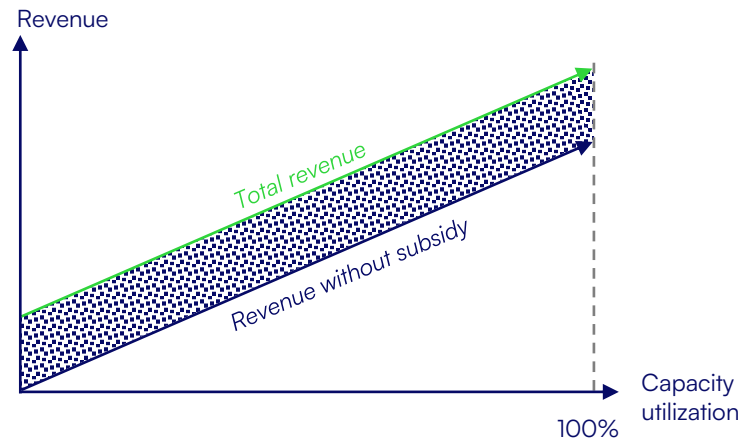
Fixed premium

Unit-price based premium linked to capacity utilization.



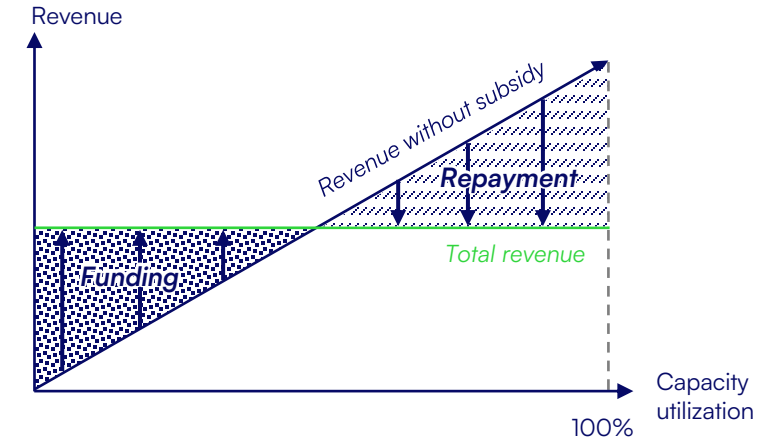
Anchor capacity bookings

Annual payments to guarantee a revenue floor.



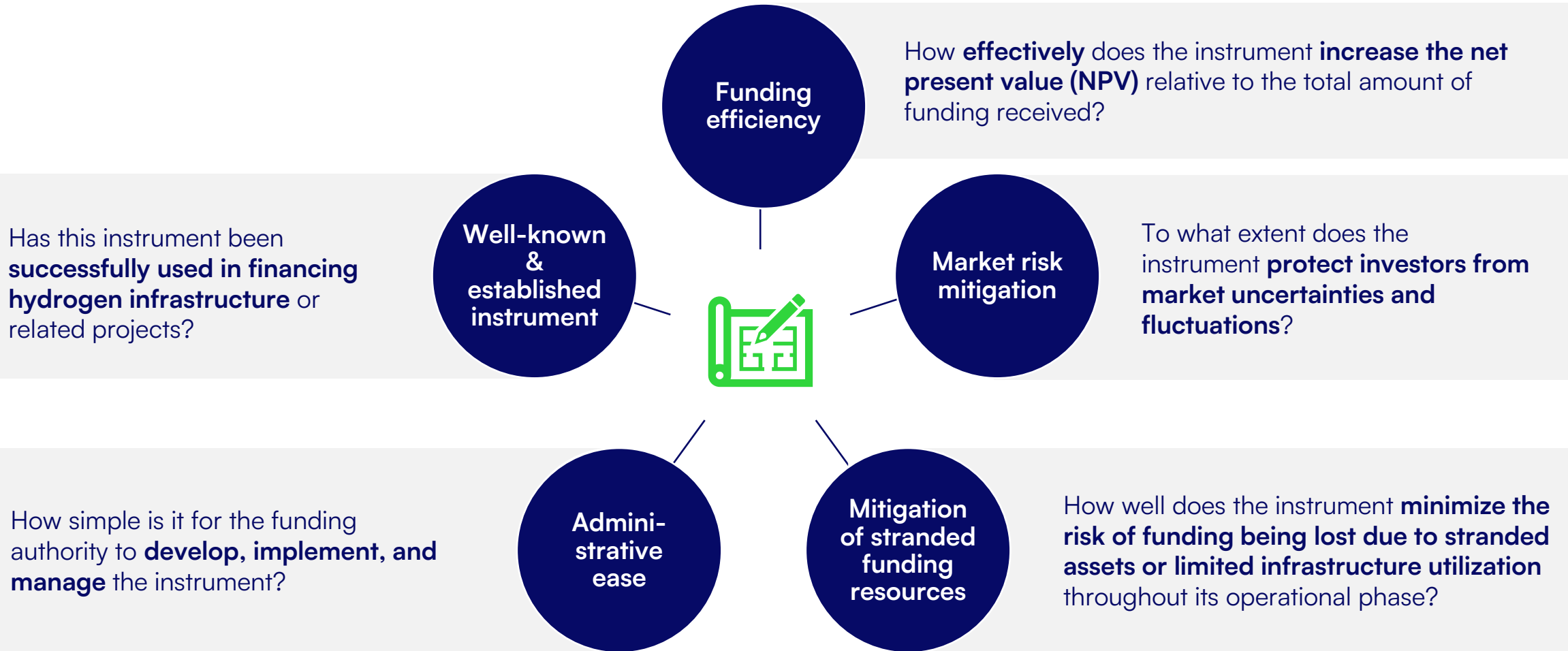
Contracts-for-difference

Revenue-based tariff to guarantee a revenue floor + claw back mechanism in case of excess revenue.



A multi-dimensional evaluation was conducted

to analyze the diverse impact of alternative financial support instruments



Results of the multi-dimensional evaluation

	CAPEX support	Fixed premium	Contracts-for-difference	Anchor capacity bookings	
Funding efficiency	1	4	2	3	
Market risk mitigation	3	4	1	2	CfDs ensure guaranteed revenue, providing full mitigation of market risks. Fixed premium instruments do not cover market risk.
Mitigation of stranded funding resources	3	1	4	2	Fixed premium schemes provide support proportional to utilization, reducing the risk of loss of funds in case of stranded assets. CfDs guarantee revenue even for stranded assets, leading to a higher risk of loss of funds since the clawback mechanism applies only to high-utilization rates.
Administrative ease for funding authority	1	3	4	2	CAPEX support only requires the definition of support criteria. CfDs require the definition of support criteria and the continuous management of the two-way financial flows.
Well-known & established instrument	1	3	2	4	CAPEX support is a commonly used instrument. Anchor capacity bookings lack a standardized definition.

Recommendations

- Develop tailored funding mechanisms for specific types of infrastructure, prioritizing **CfDs** for high-risk, long-term projects like pipelines and underground storage, and **CAPEX support** for simpler, lower-cost projects like terminals and reconversion facilities.
- **Anchor capacity bookings** constitute a viable alternative for all types of infrastructure.

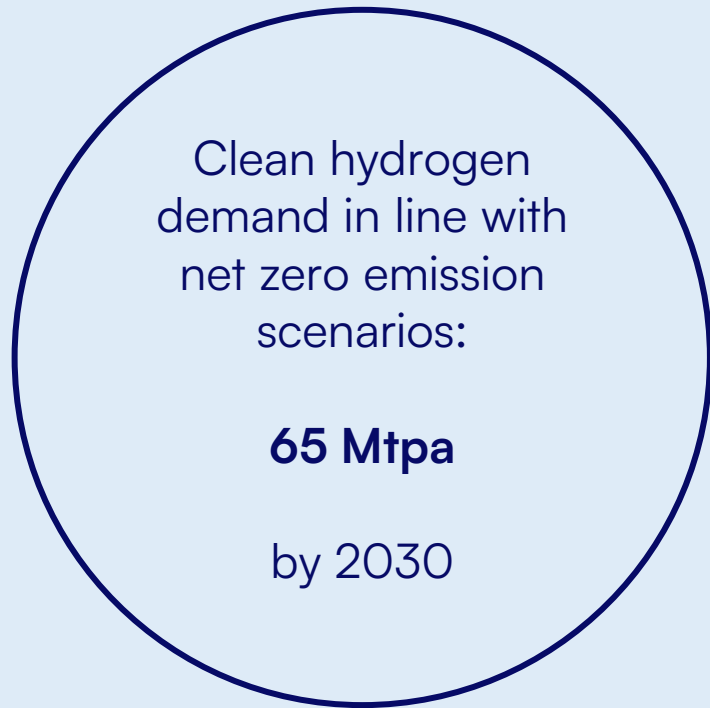
Suitability of financial support instruments by infrastructure

	CAPEX	Fixed premium	Contracts-for-difference	Anchor capacity bookings
Pipeline	Medium	Low	High	Medium
Terminal	High	Low	Medium	Medium
Reconversion	High	Low	Medium	Medium
Underground storage	Medium	Low	High	Medium



Unlocking potential: Scaling demand through hydrogen hubs

Projected demand for clean hydrogen and its derivatives is high but firm offtake commitments remain low



Share of supply projects with firm offtake:

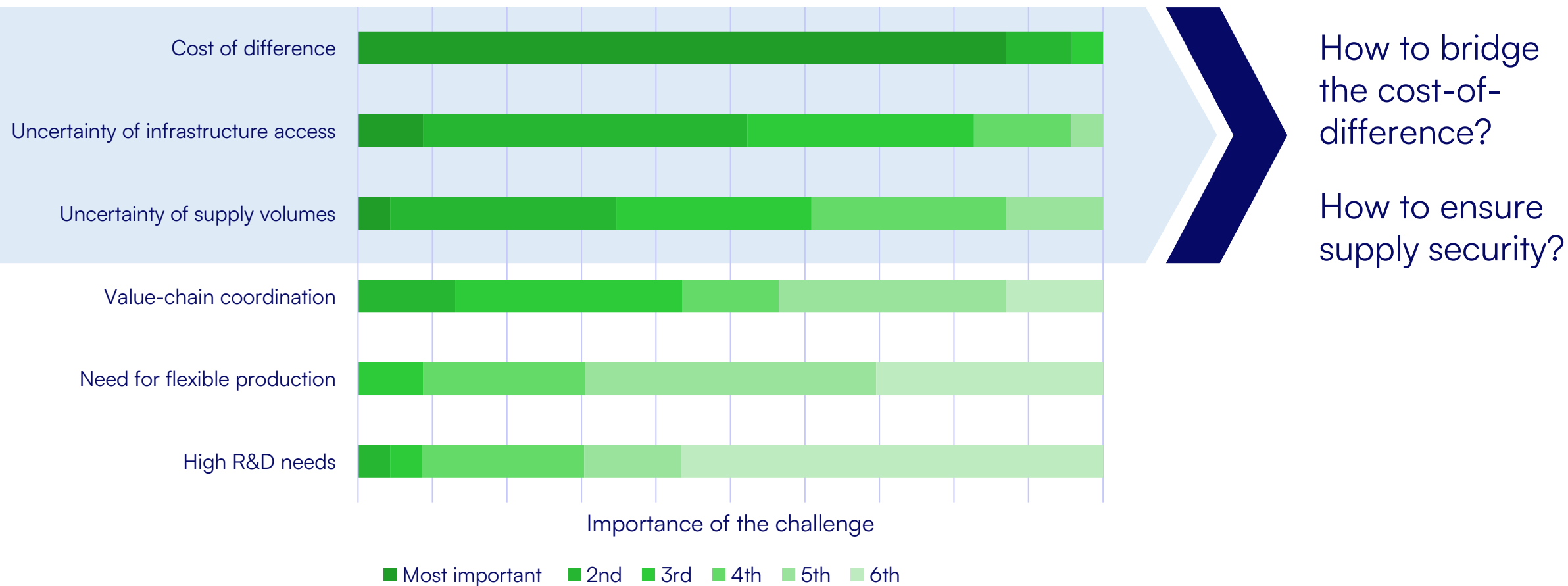


in 2024



What inhibits demand uptake?

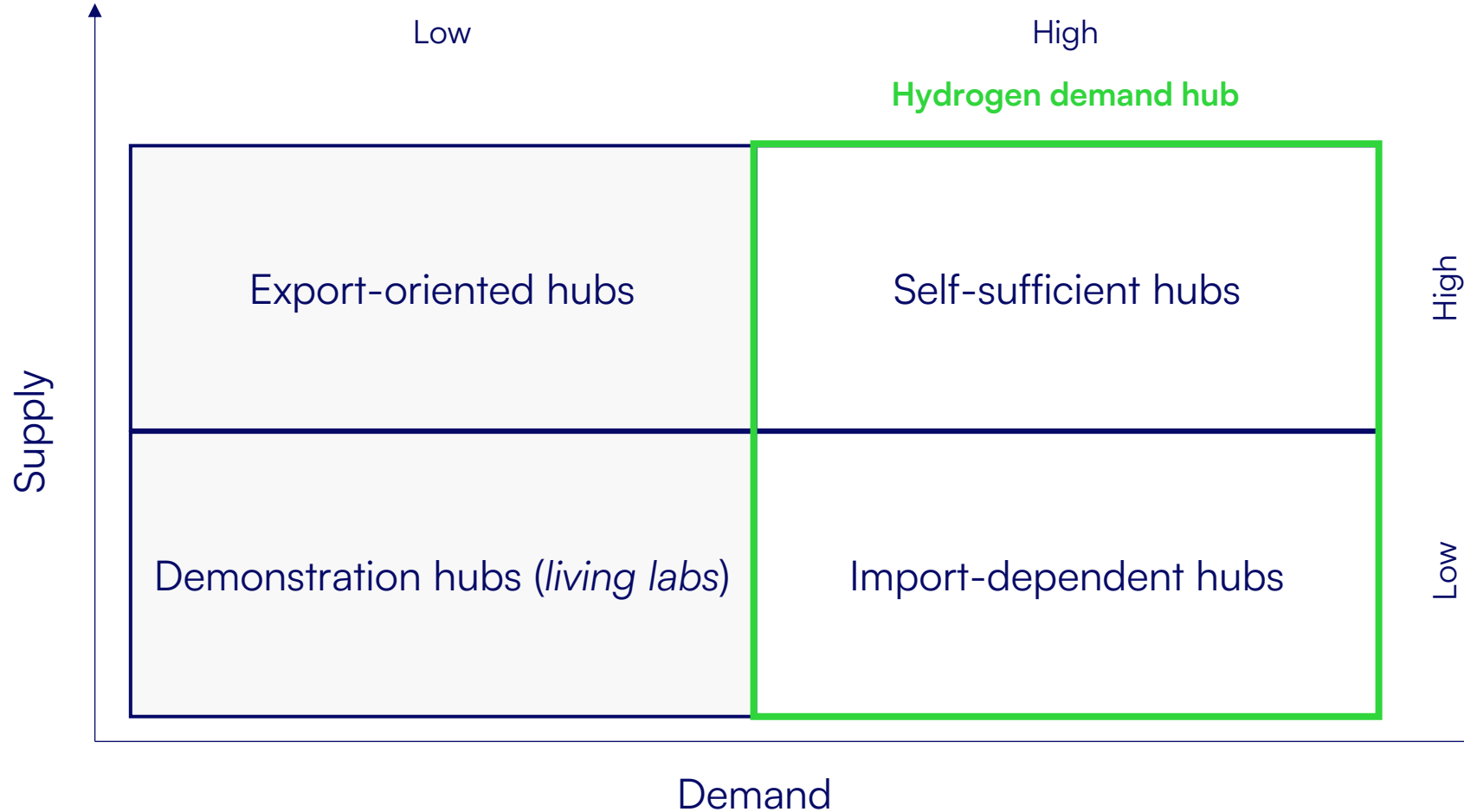
Offtakers worry mostly about cost-of-difference & supply security



Source: H2Global survey among donors to the H2Global Foundation on priority challenges for potential clean hydrogen off-takers; n=23

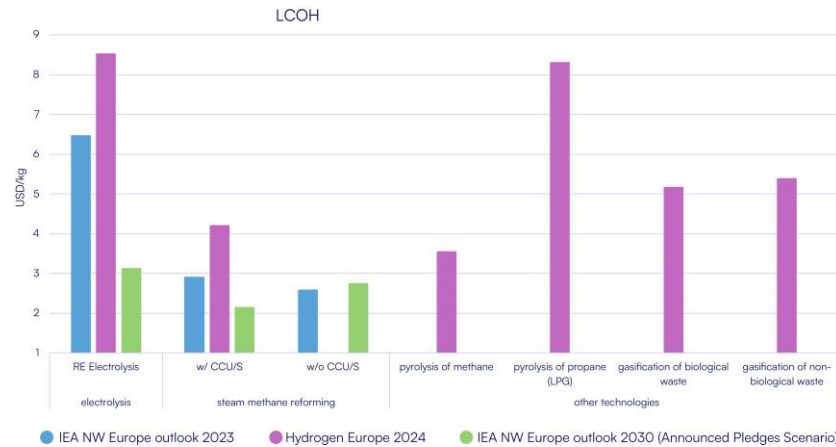
Hydrogen hubs can take different forms

depending on the emphasis given to supply and demand



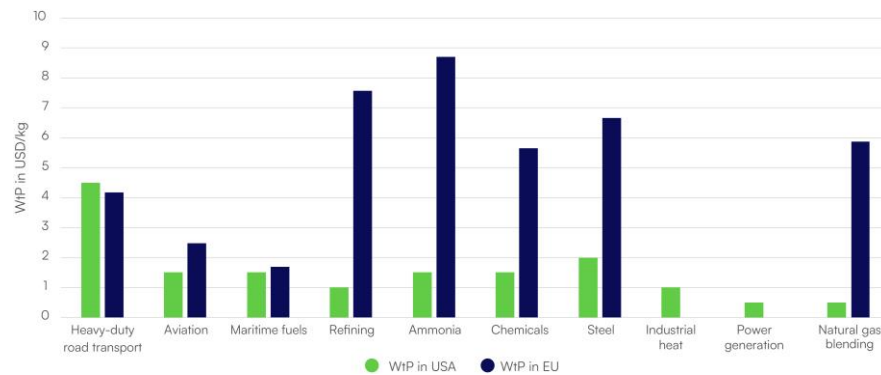
Cost-of-difference

is addressed differently in the two demand hubs



SELF-SUFFICIENT HUBS

- Select production technologies to match the willingness to pay (WtP)
- Reduce infrastructure costs through proximity

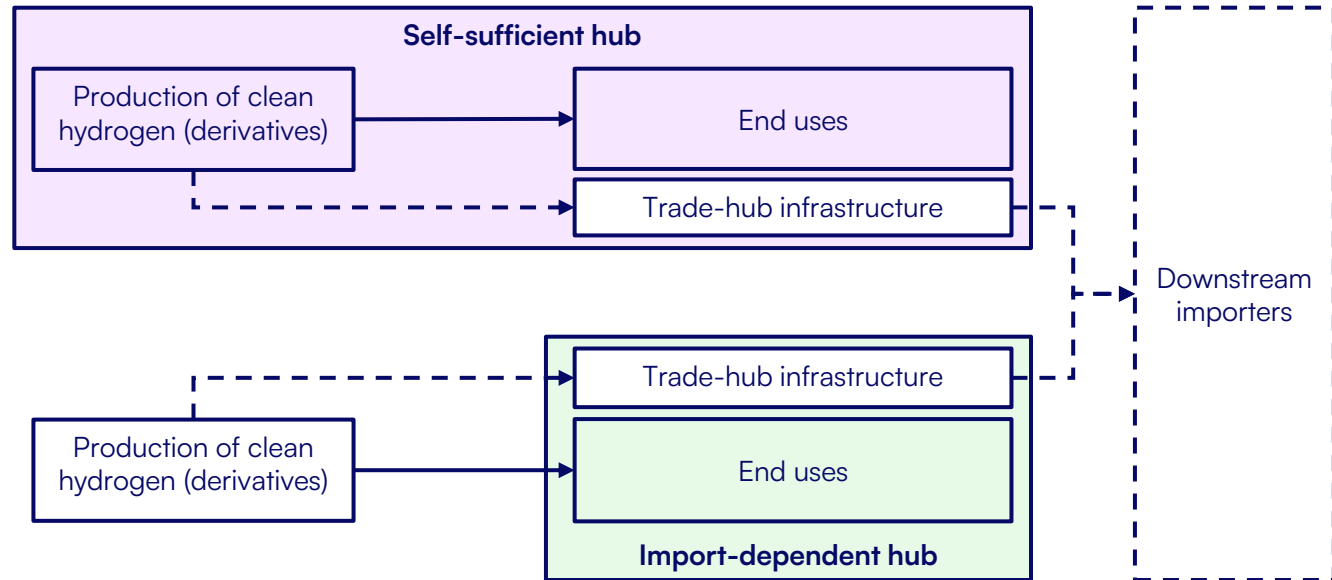


Sources for WtP rely on different methodologies

IMPORT-DEPENDENT HUBS

- Optimize location to match most economic supply
- Leverage collective buying power

Infrastructure access and security of supply are tackled in distinct ways by the two demand hubs



SELF-SUFFICIENT HUBS

- Supply matches demand within the hub
- Infrastructure requirements are lower since distances are relatively short within the hub

IMPORT-DEPENDENT HUBS

- Focus investment in the development of import terminals and/or transport corridors



The development of a **trade hub** is not directly related to offtake and thus an optional feature

Different transformation pathways need different solutions

Challenge	Self-sufficient hubs	Import-dependent hubs
Cost-of-difference	• CAPEX for CCUS assets or other captive supply assets • OPEX with reference to additional electricity cost	• CAPEX for industrial assets • OPEX with reference to previously used fossil fuel
Supply security	• Ensuring sufficient local production and direct connection with offtakers	• Collective procurement from external supply, import coordination
Infrastructure	• Within-hub pipelines	• Import terminals, long-distance/mid-stream pipelines



Keep it simple:
Aligning auction
objectives for success

Auctions are key to jumpstarting clean hydrogen markets, revealing prices and attracting investment

CHALLENGES



No clear pricing signal on supply or demand for clean hydrogen and its derivatives



Limited number of transactions



Differences between cost & willingness to pay

AUCTIONS



enable competitive price discovery



connect hydrogen supply with demand



allocate financial support

Auctions are a flexible instrument

able to accommodate various policy objectives

Fiscal objectives
Industry policy objectives
Social objectives
Trade policy objectives
Environmental objectives

...

**Different
objectives
may lead to
trade-offs**

Assessment of 22 auction objectives and their interactions

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]
[1] supporting H2 (derivative) market creation	0	2	2	2	3	-1	-2	-2	2	2	0	0	0	0	0	0	1	-1	-2	0	-2	2
[2] reducing cost of H2 (derivatives) for offtakers	2	0	2	2	2	-1	-2	0	2	2	-1	-1	-1	0	2	0	2	-1	2	0	0	0
[3] maximizing economies of scale	2	2	0	0	0	-1	-1	-2	2	2	1	-1	1	0	0	0	0	0	0	-2	-1	2
[4] supporting value chain establishment	0	0	0	0	-2	0	0	2	0	0	1	0	0	0	0	0	0	2	2	1	-2	-1
[5] increasing H2 (derivatives) market liquidity	3	0	0	-2	0	2	2	0	0	0	0	0	0	0	0	2	0	0	0	0	-1	-2
[6] diversifying energy supply geographies	-1	-1	-1	0	2	0	2	0	2	0	0	2	1	-2	-1	0	0	0	0	0	-2	-1
[7] diversifying energy supply companies	2	-2	-1	0	2	2	0	1	0	0	0	1	0	0	0	2	0	0	0	0	0	-2
[8] ensuring project completion	2	-2	0	2	0	0	1	0	2	2	1	1	1	2	2	1	0	1	1	-2	-2	0
[9] reducing global GHG emissions	2	2	2	0	0	0	0	2	0	-2	0	2	2	0	0	0	0	0	0	0	0	-1
[10] reducing domestic GHG emissions	0	-2	0	0	0	0	0	2	-2	0	0	1	-1	2	1	0	0	0	0	0	0	-1
[11] supporting social sustainability and local value creation	0	-1	0	0	0	0	0	0	0	0	0	1	2	0	0	2	0	0	1	-1	-1	-1
[12] supporting environmental sustainability beyond GHG emissions	0	-1	-1	0	0	0	1	1	2	1	1	0	0	0	0	2	2	0	1	-1	-1	-1
[13] supporting development policy targets	0	-1	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	-1	-2	-2
[14] supporting domestic supply market development	0	0	0	0	0	-2	0	0	0	2	0	0	0	0	0	0	0	1	2	0	2	-1
[15] enhancing national industrial competitiveness	0	2	0	0	0	0	0	-2	0	1	0	0	0	0	0	0	2	0	0	0	2	-2
[16] supporting SMEs	0	0	0	0	2	0	2	1	0	0	2	0	0	0	0	0	0	0	0	1	0	0
[17] fostering H2 (derivative) innovation	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	-2	-1	0	-1	1
[18] developing specific technologies	0	-1	0	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0	2	1	1	-1
[19] developing specific (offtake) sectors	0	0	0	2	0	0	0	1	0	0	1	1	0	2	0	0	0	1	0	0	1	-2
[20] minimizing time to delivery	0	0	-2	1	0	0	0	-2	0	0	-1	-1	-1	0	0	0	0	0	1	0	1	-2
[21] minimizing duration of award procedure	-2	0	0	0	0	-2	0	-2	0	0	-1	-1	-2	2	0	0	0	0	0	1	0	0
[22] maximizing fiscal efficiency	2	0	2	0	0	-1	0	0	-1	-1	-1	-1	-2	-1	2	0	0	-1	-1	0	0	0

Fiscal efficiency is the objective with the most trade-offs

Legend

The table reads that the objectives in the rows impact those listed in the columns.

0 = no or ambiguous effect
>0 = synergistic/positive effect
<0 = negative effect

|1| = weak relation
|2| = intermediate relation
|3| = strong relation

Supporting SMEs is the only objective that has no negative relationship to any of the other objectives analyzed

Four clusters allow auction designers to pick coherent objectives with maximum synergies and minimum trade-offs

- 1 supporting H2 (derivatives) market creation
- 2 reducing cost of H2 (derivatives) for offtakers
- 3 maximizing economies of scale
- 4 supporting value chain establishment
- 5 increasing H2 (derivatives) market liquidity
- 6 diversifying energy supply geographies
- 7 diversifying energy supply companies
- 8 ensuring project completion
- 11 supporting social sustainability and local value creation
- 12 supporting environmental sustainability beyond GHG emissions
- 13 supporting development policy targets
- 16 supporting SMEs

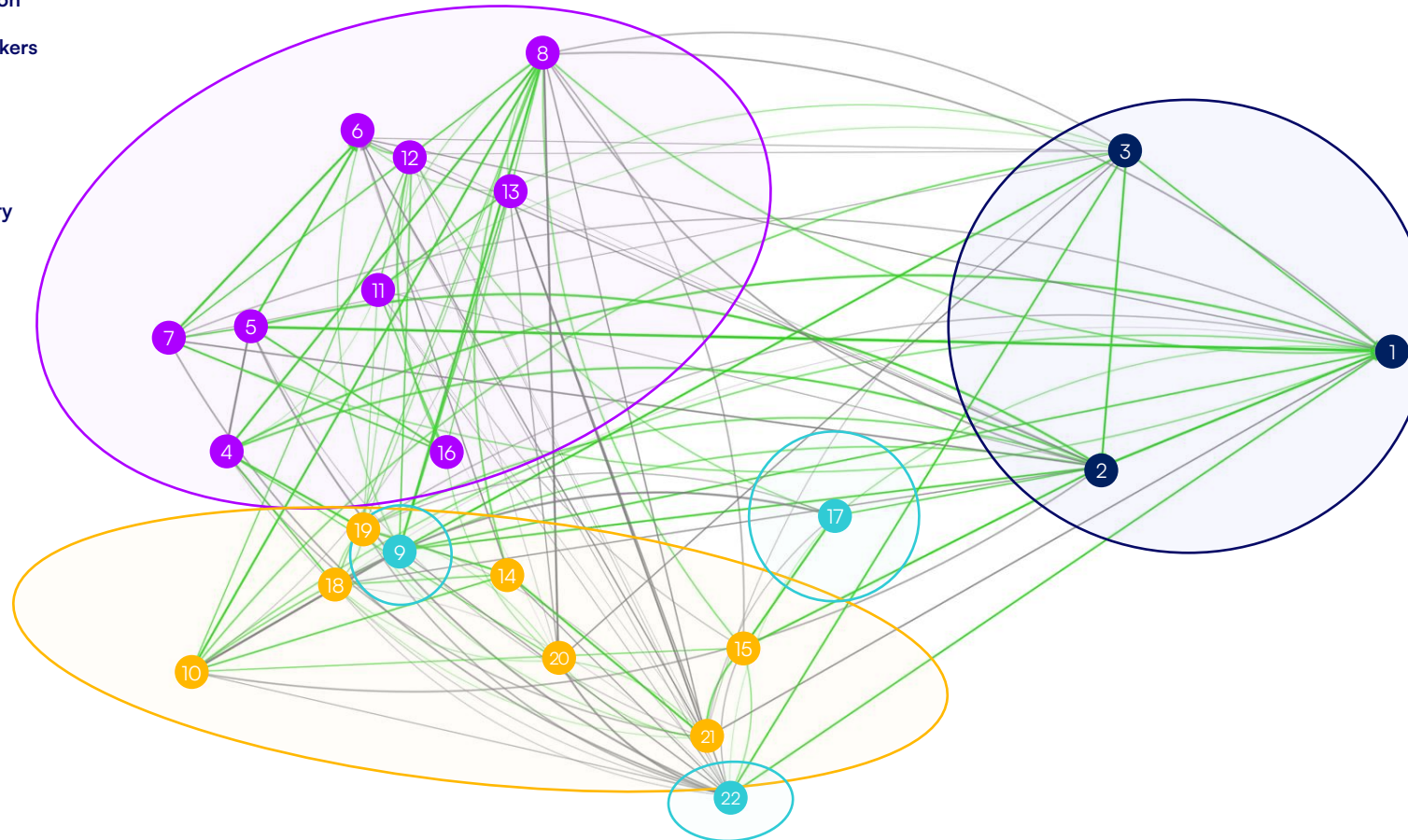
Arrow effects

→ Positive effect → Negative effect

Clusters

- Scale objectives
- Sustainability and resilience objectives
- Speed and domestic development objectives
- Efficiency objectives

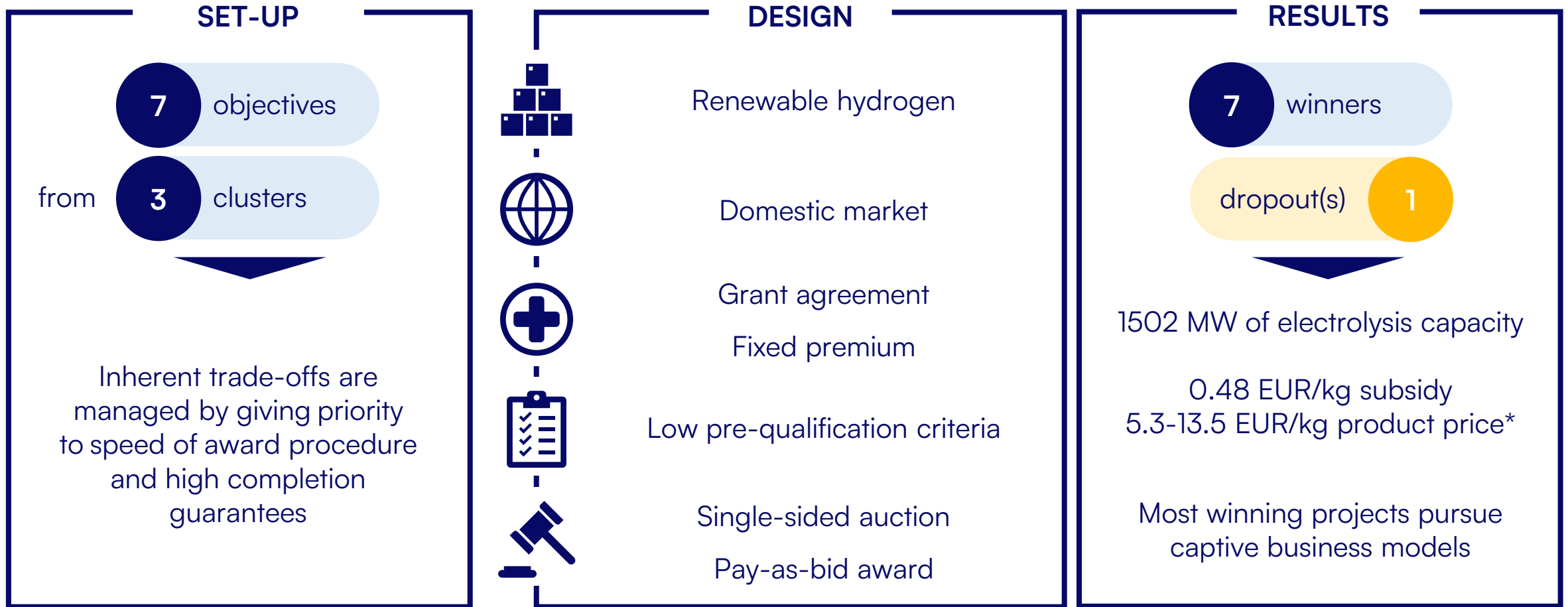
- 9 reducing global GHG emissions
- 17 fostering H2 (derivatives) innovation
- 22 maximizing fiscal efficiency



- 10 reducing domestic GHG emissions
- 14 supporting domestic supply market development
- 15 enhancing national industrial competitiveness
- 18 developing specific technologies
- 19 reducing global GHG emissions
- 20 minimizing time to delivery
- 21 minimizing duration of award procedure

The European Hydrogen Bank Pilot Tender

features more objectives, with an internal prioritization for speed in practice



*range of average LCOH per country

The H2Global Pilot Auction for Renewable Ammonia

has the largest number of objectives



*Calculation by H2Global team as the official bid contained an ammonia price

Recommendations

*Non-exhaustive list

KEY CHALLENGES ARE...*



False equivalence between dissimilar auction processes



Inherent trade-offs of multiple objectives

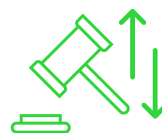


Immature clean hydrogen markets

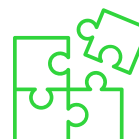
SOLUTIONS INCLUDE...*



Use of coherent sets of auction objectives & like-for-like comparison based on objectives



Reduction of incentives for underbidding & underbuilding



Implementation of general political goals through policies (not forcing them into auctions)



Enabling of regulatory exceptions for immature market settings



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