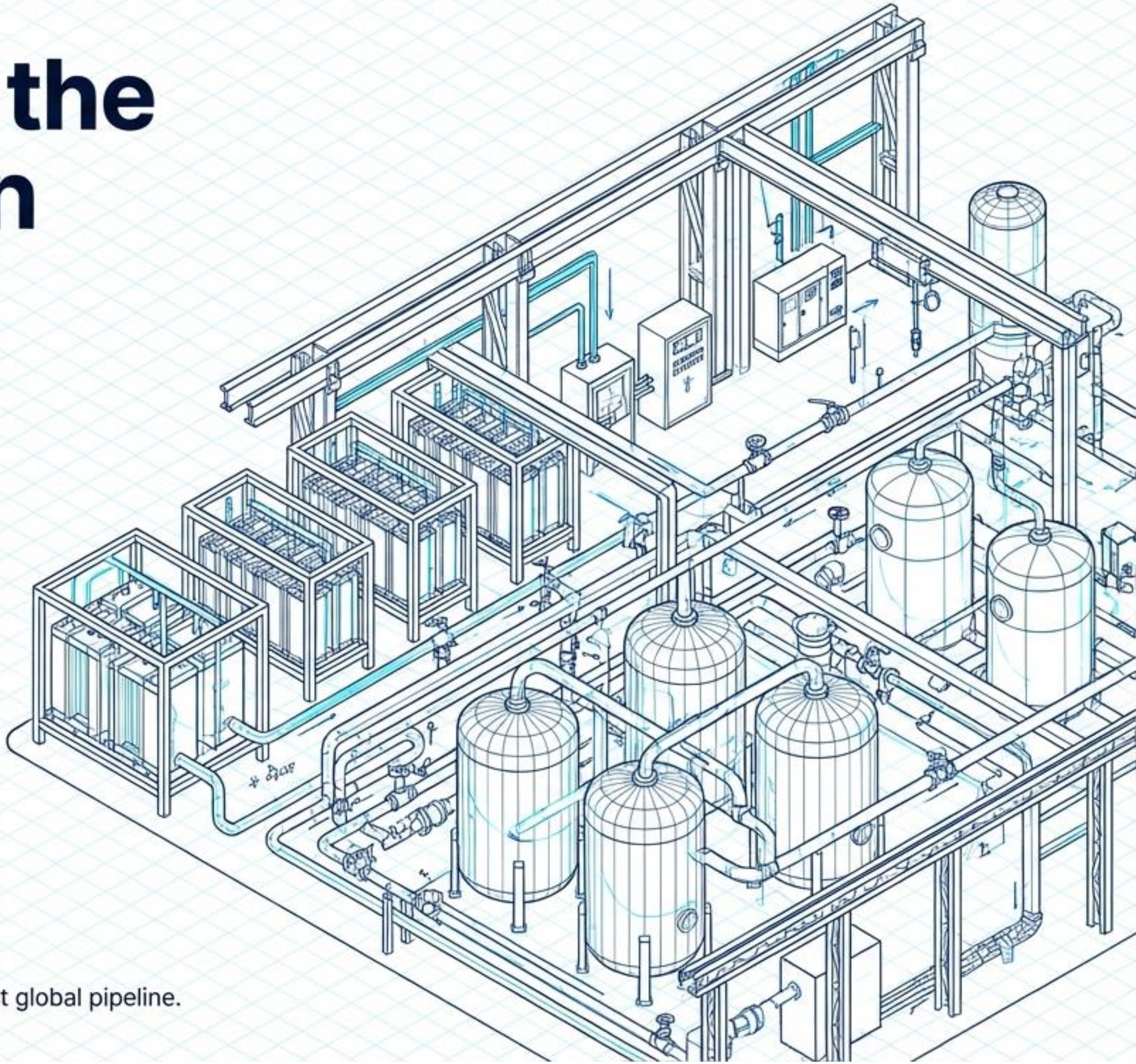
Deconstructing the Global Hydrogen Blueprint

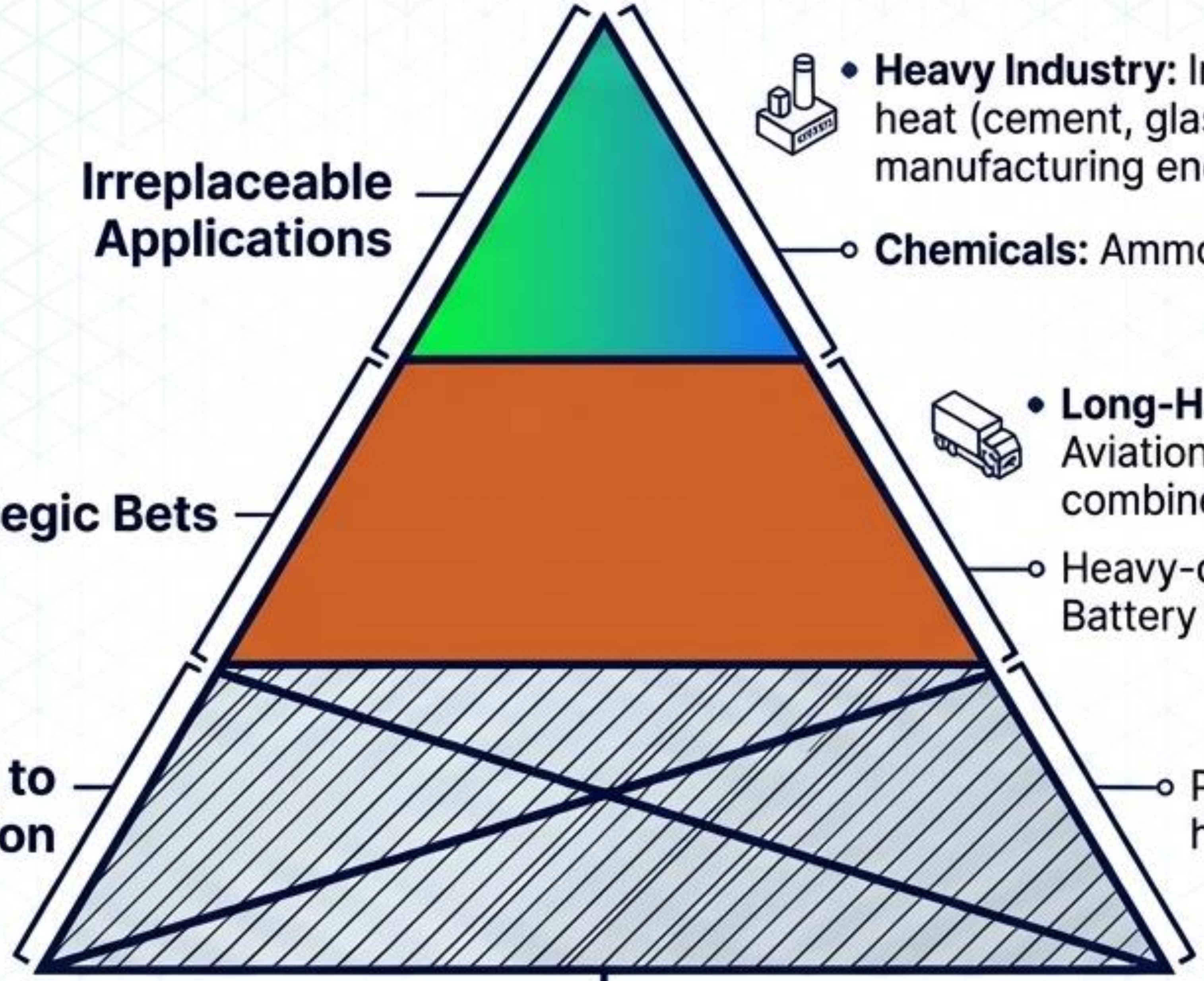
Pathways, economics, and strategic realities of the transition to 2050.



[1]Based on qualitative and quantitative analysis of the 1,500+ project global pipeline.

The ‘chicken-and-egg’ dilemma between supply and demand, coupled with severe cost inflation, is stalling the operational rollout required for Net-Zero.

The ‘No-Regret’ Demand Pyramid



Irreplaceable Applications

- **Heavy Industry:** Iron & Steel (DRI), high-temperature heat (cement, glass). Forecast: 73% of manufacturing energy demand by 2050.
- **Chemicals:** Ammonia and methanol feedstocks.

Strategic Bets

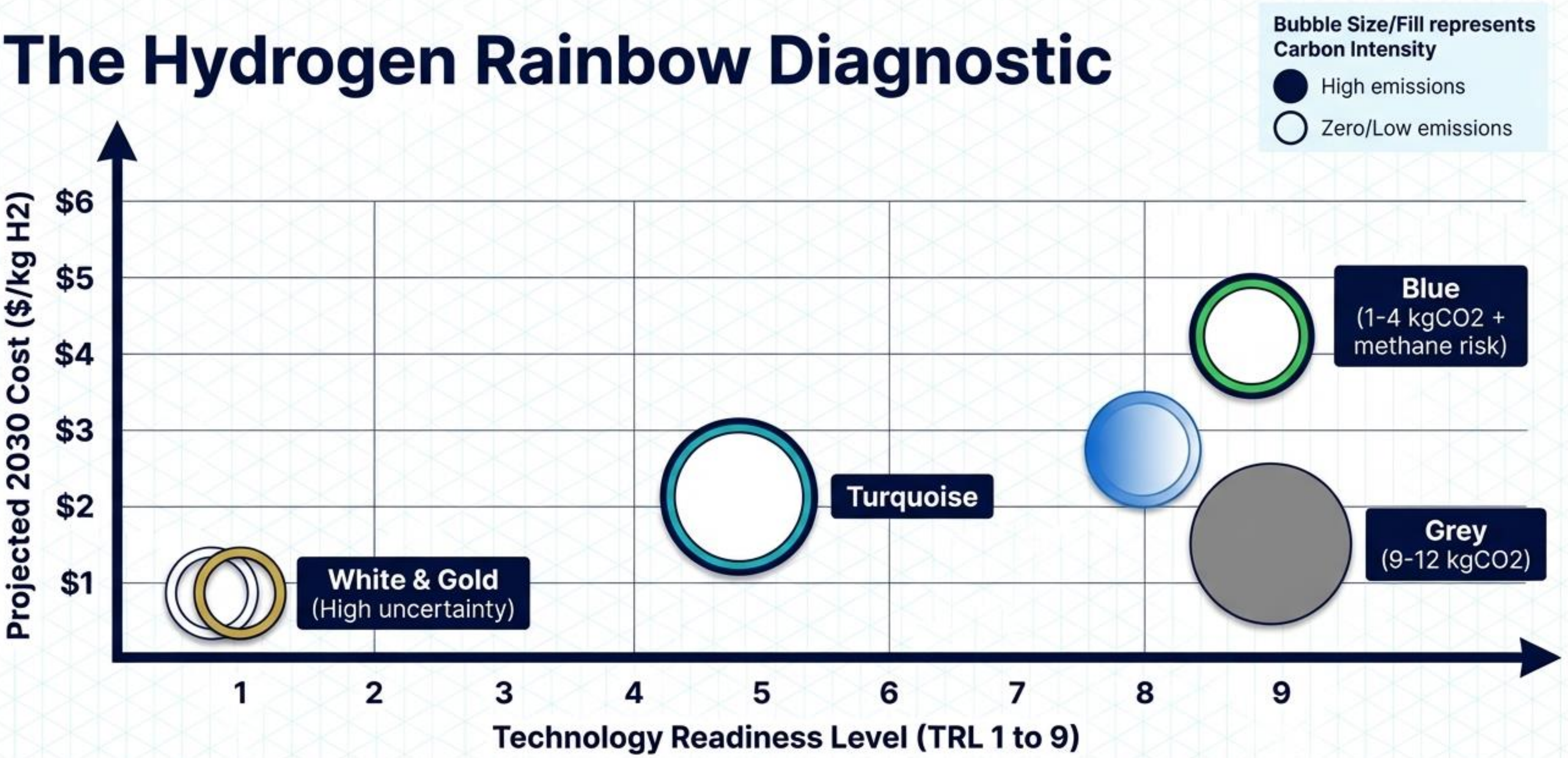
- **Long-Haul Transport:** Shipping (Ammonia) & Aviation (e-kerosene). Forecast: ~65 Mtpa combined by 2050.
- Heavy-duty trucking (competing tightly with Battery EVs).

Losing to Electrification

- Passenger BEVs and residential home heating.

The total addressable market will reach up to 660 Mtpa by 2050, but success depends on pivoting away from the ‘hydrogen for everything’ narrative to laser-focusing on hard-to-abate industrial sectors.

The Hydrogen Rainbow Diagnostic



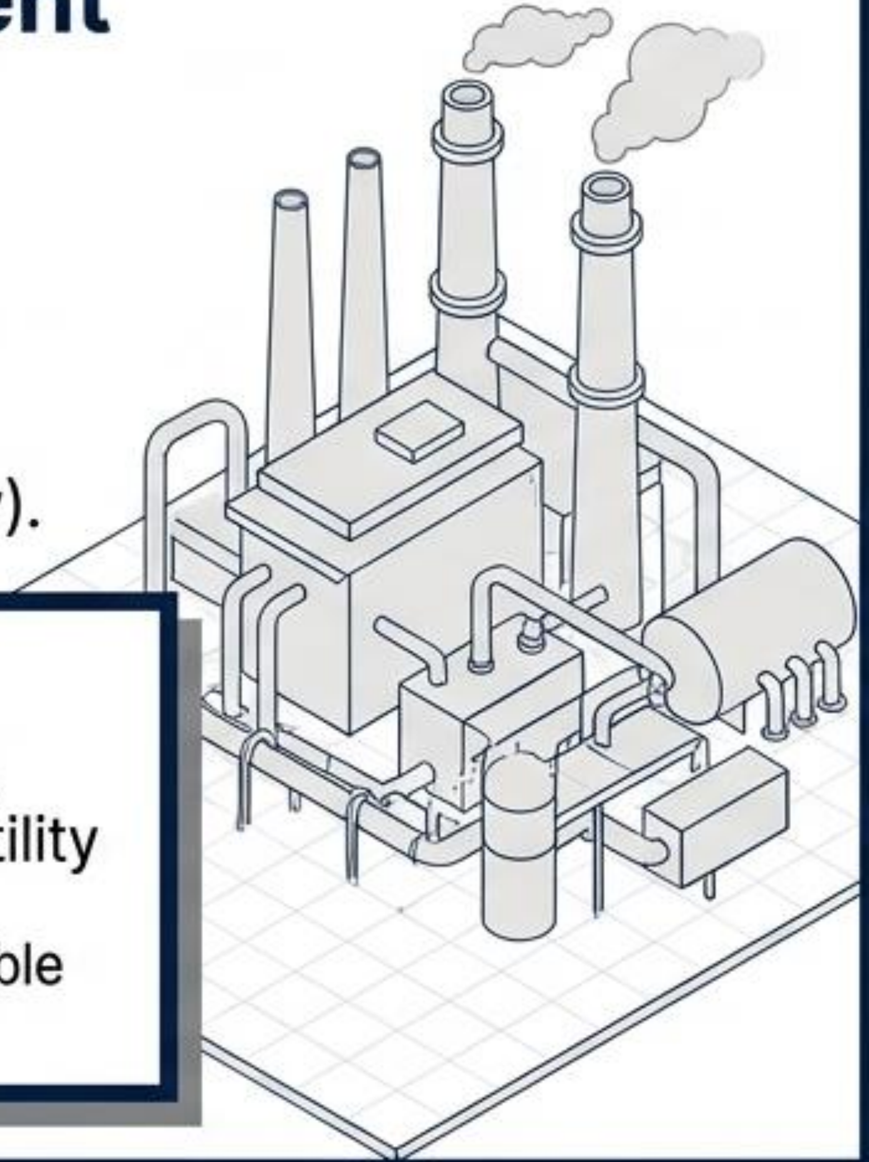
True climate impact hinges on a quantitative full lifecycle assessment, prompting regulatory shifts toward strict emissions intensity thresholds rather than simple colour codes.

Fossil-Based Pathways: Economics vs. Emissions

The Incumbent

Technology:
Steam Methane Reforming (SMR).

Cost:
$1.00 - $3.00/kg
(Lowest cost globally).



The Fatal Flaw

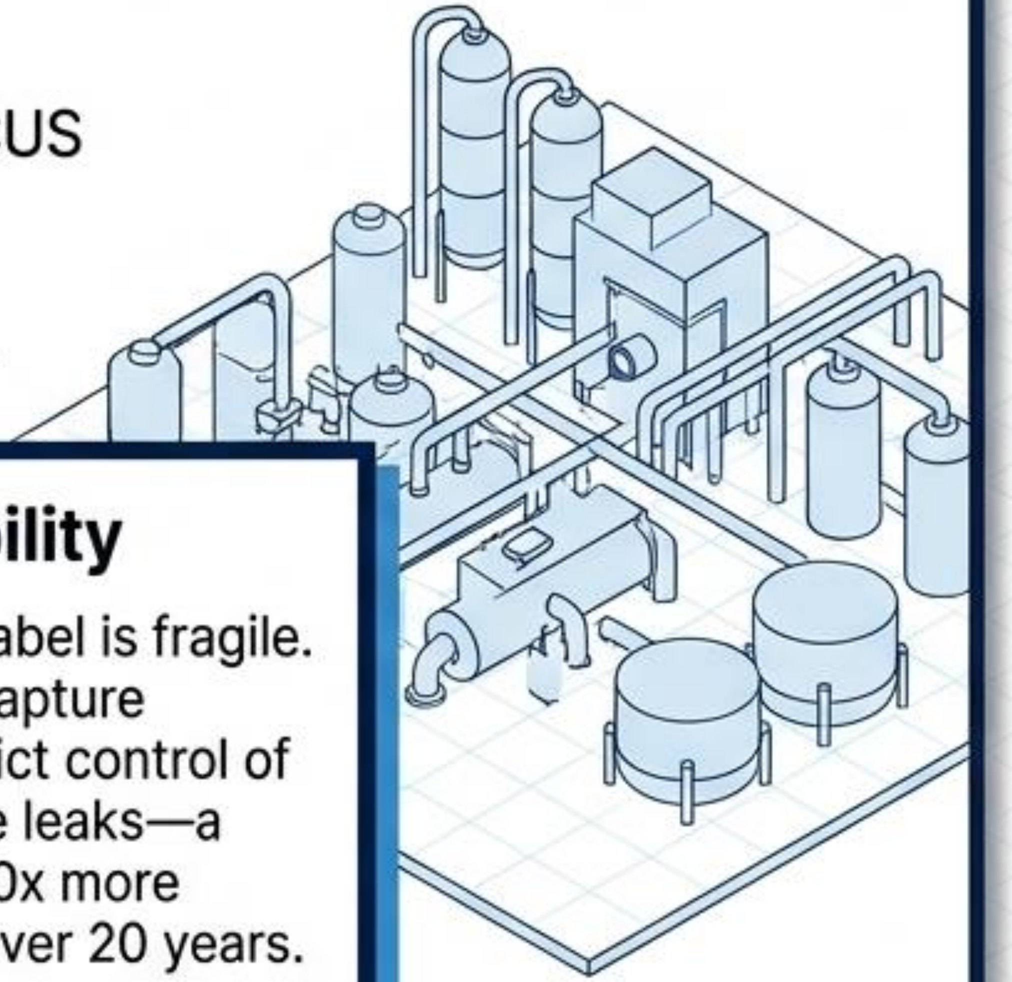
High CO_2 emissions, fossil fuel price volatility

Completely incompatible with climate targets.

The Bridge

Technology:
SMR or ATR + CCUS

Cost (2030):
$1.50 - $2.20/kg.



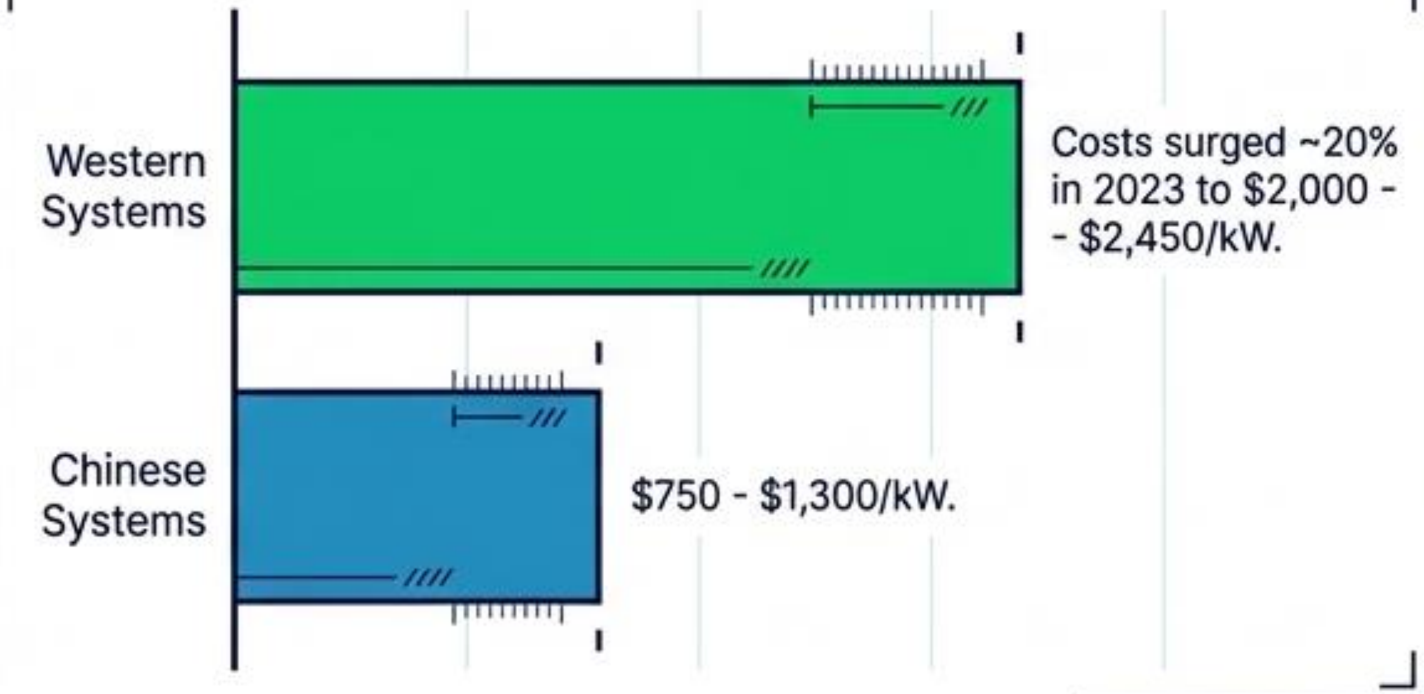
The Vulnerability

The 'low-carbon' label is fragile. It requires >90% capture efficiency AND strict control of upstream methane leaks—a greenhouse gas 80x more potent than CO2 over 20 years.

Blue hydrogen is economically viable today (aided by U.S. IRA 45Q/45V tax credits) but carries massive long-term verification and permanent storage risks.

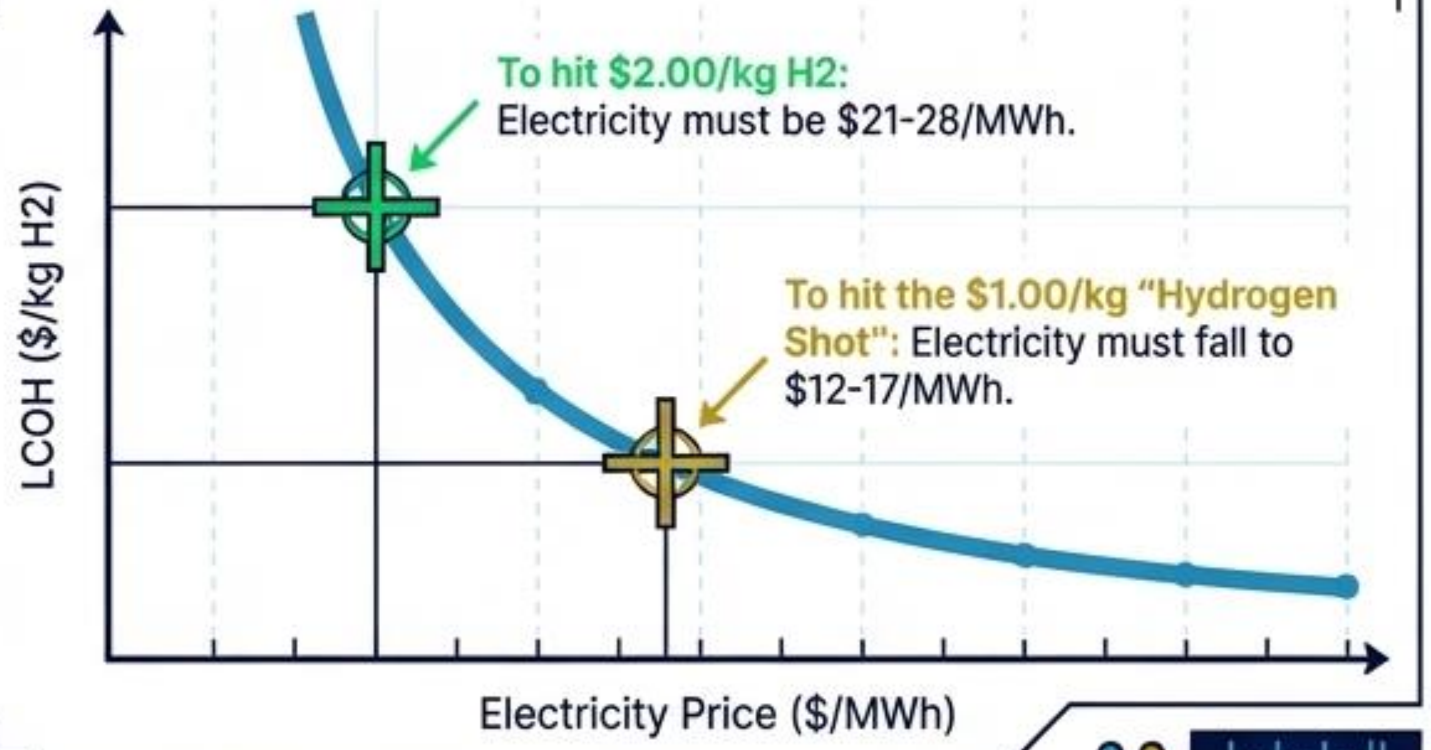
The Ultimate Endgame: Green Hydrogen's Economic Headwinds

Gauge 1: Electrolyser CAPEX Inflation



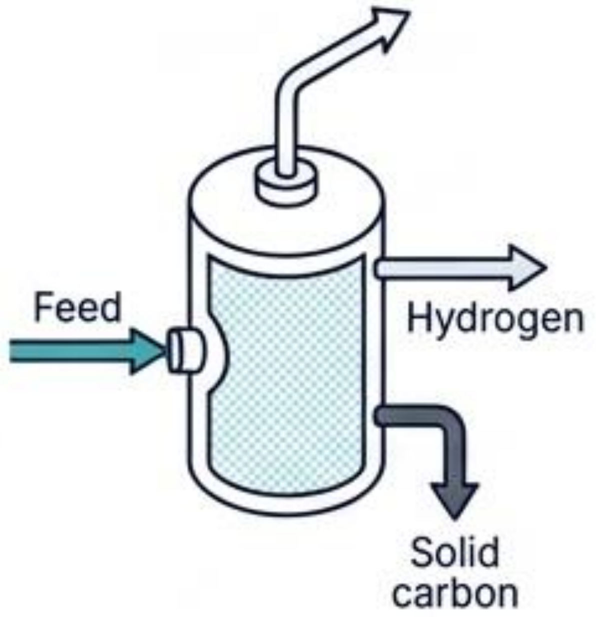
Takeaway: Supply chain inflation forces difficult strategic procurement choices for Western developers.

Gauge 2: The Ruthless Math of Power Prices



Takeaway: These prices are practically unattainable via standard retail grids, demanding massive, dedicated, hyper-efficient renewable installations.

The Wildcards: Disruptive Extraction Technologies

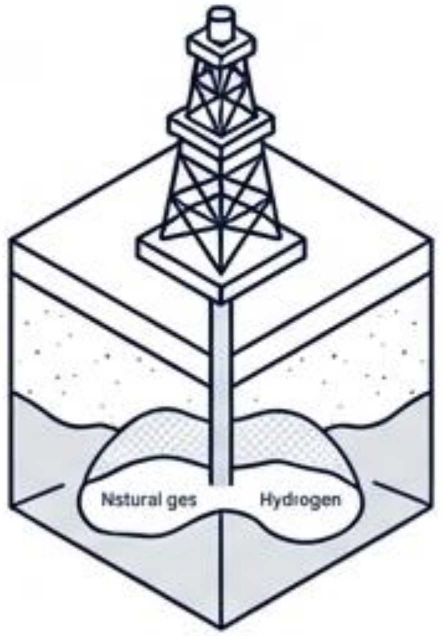


Turquoise (Methane Pyrolysis)

Mechanism: Thermal decomposition of methane into H2 and solid carbon.

Target Cost: $1.00-$3.00/kg.

The Catch: Requires the development of massive, stable markets for the solid carbon byproduct (tyres, pigments) to subsidise costs.

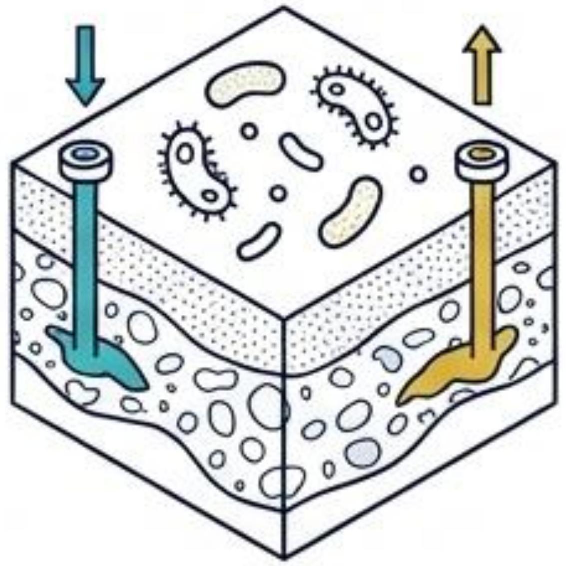


White (Geological)

Mechanism: Extraction of natural deposits (like Bourakébougou, Mali).

Target Cost: <$1.00/kg (avoids manufacturing entirely).

The Catch: Trillions of tonnes exist, but recoverability, purity, and environmental impact (drilling/fracking) are entirely unproven (TRL <4).



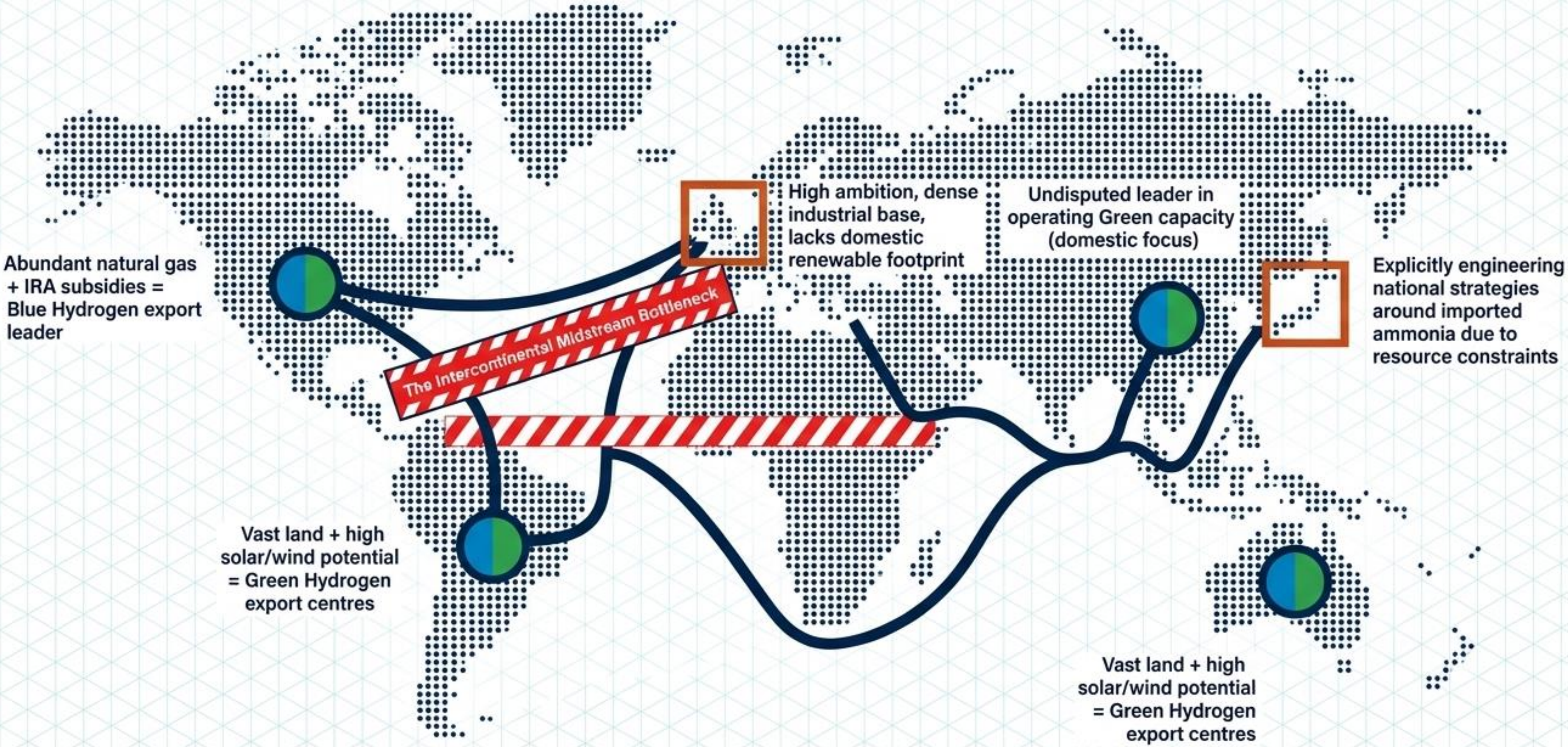
Gold (Biotechnological)

Mechanism: Injecting microbes into depleted oil reservoirs to consume hydrocarbons.

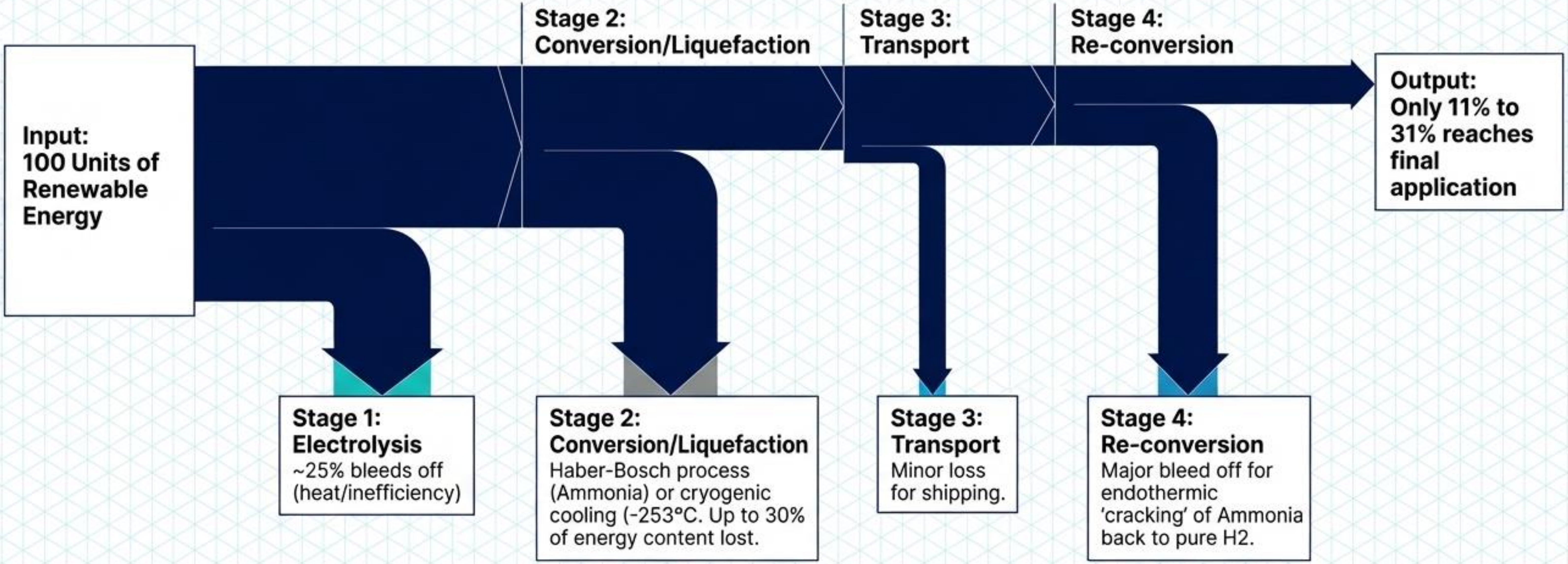
Target Cost: <$0.50/kg (game-changing).

The Catch: Severe purity issues (early trials hit only 40% H2), requiring highly energy-intensive purification.

The Global Macro-Flow: Geographic Mismatch



The Physics of the Midstream Energy Penalty



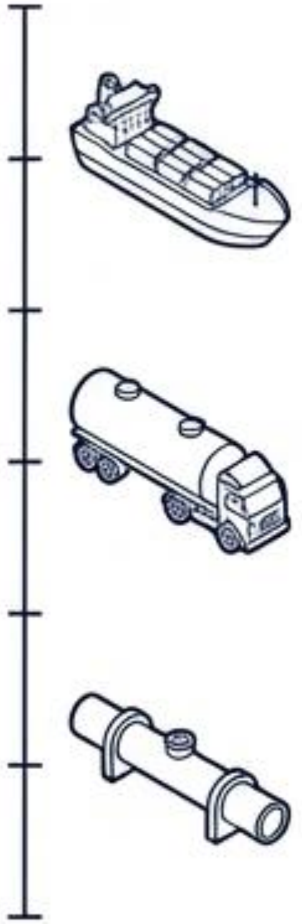
For intercontinental trade, conversion and transport energy penalties routinely exceed the initial cost of production.

The Carrier Conundrum

Carrier	Transport State	8,000km Transport Cost	Primary Drawback
Liquid Hydrogen (LH2)	Cryogenic (-253°C)	\$2.00 - \$3.70/kg	Extreme energy penalty to liquefy; continuous 'boil-off' losses during transit.
Ammonia (NH3)	Liquid (-33°C)	\$1.90 - \$2.20/kg (cracked) / <\$1.00 (direct fuel)	Highly toxic; terrible round-trip efficiency requiring massive energy to crack back to pure H2.
Liquid Organic Carriers (LOHC)	Ambient Liquid (binds H2 to oils like toluene)	\$2.00 - \$2.50/kg	Safest, but carrier liquid adds massive dead-weight, and dehydrogenation is highly energy-intensive.

The Infrastructure Advantage: Land vs. Sea

The Transport Cost Curve



Shipping (2030)

$16 - $31/GJ (Current LNG is only $3-$7/GJ)

Trucking

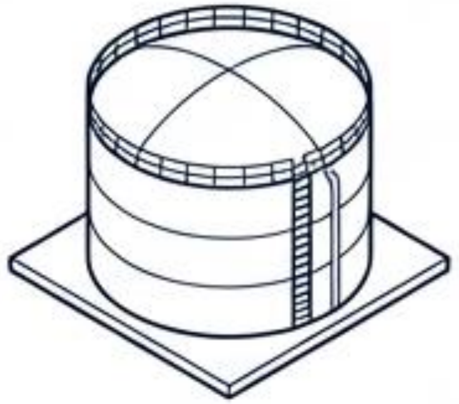
$2.01 - $3.80/kg (Highly sensitive to distance; viable only for 'last mile')

Repurposed Pipelines

$0.14 - $0.31/kg

Crucial insight: Repurposing existing natural gas pipelines costs only 10-35% of building new ones.

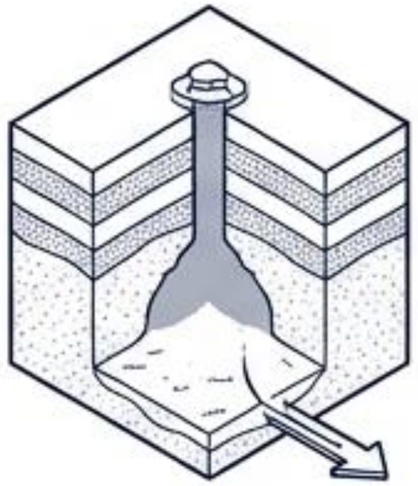
The Scale of Storage



Above-Ground Tanks

$1.39/kg

(Short duration buffering only)



Geological Salt Caverns

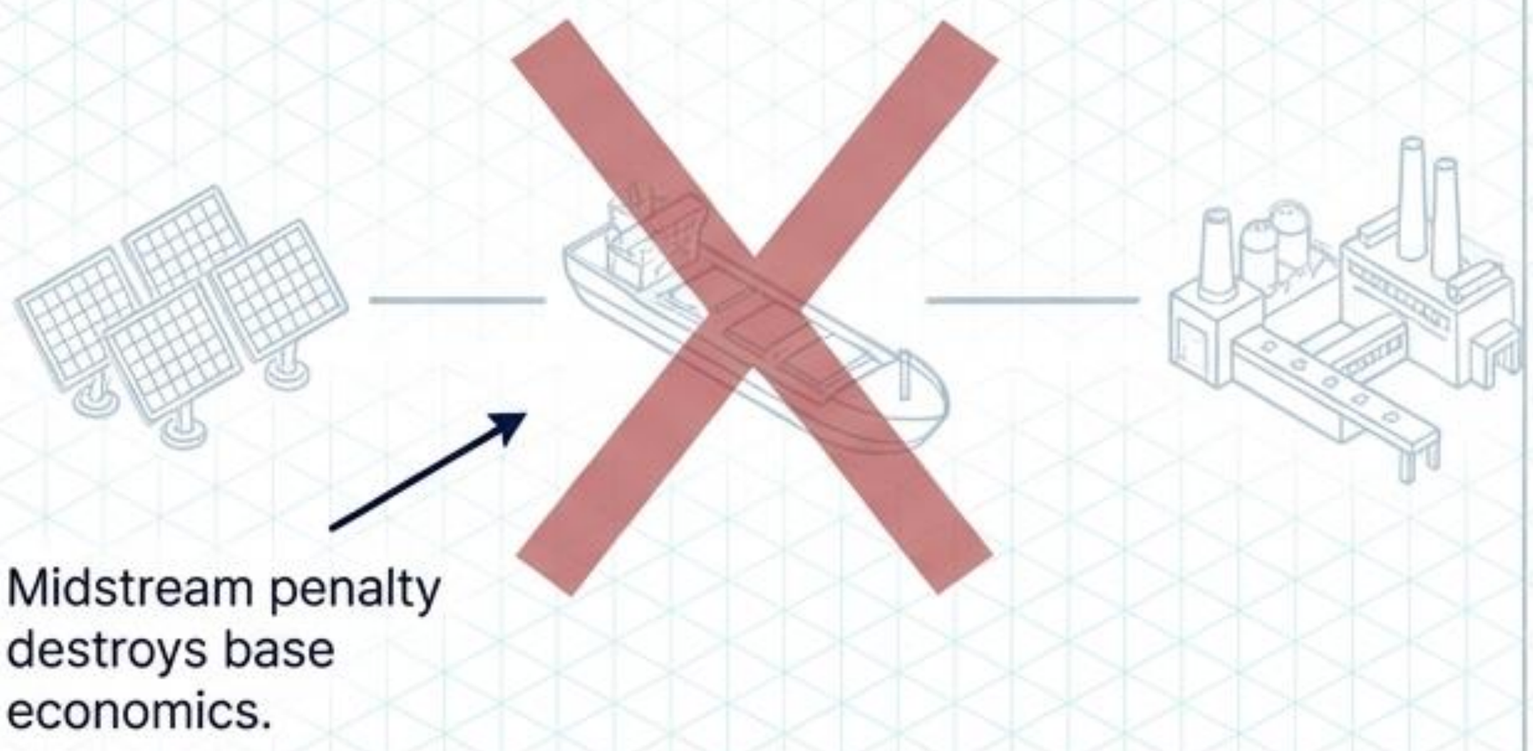
$0.23 - $0.26/kg

(Long duration, grid-scale)

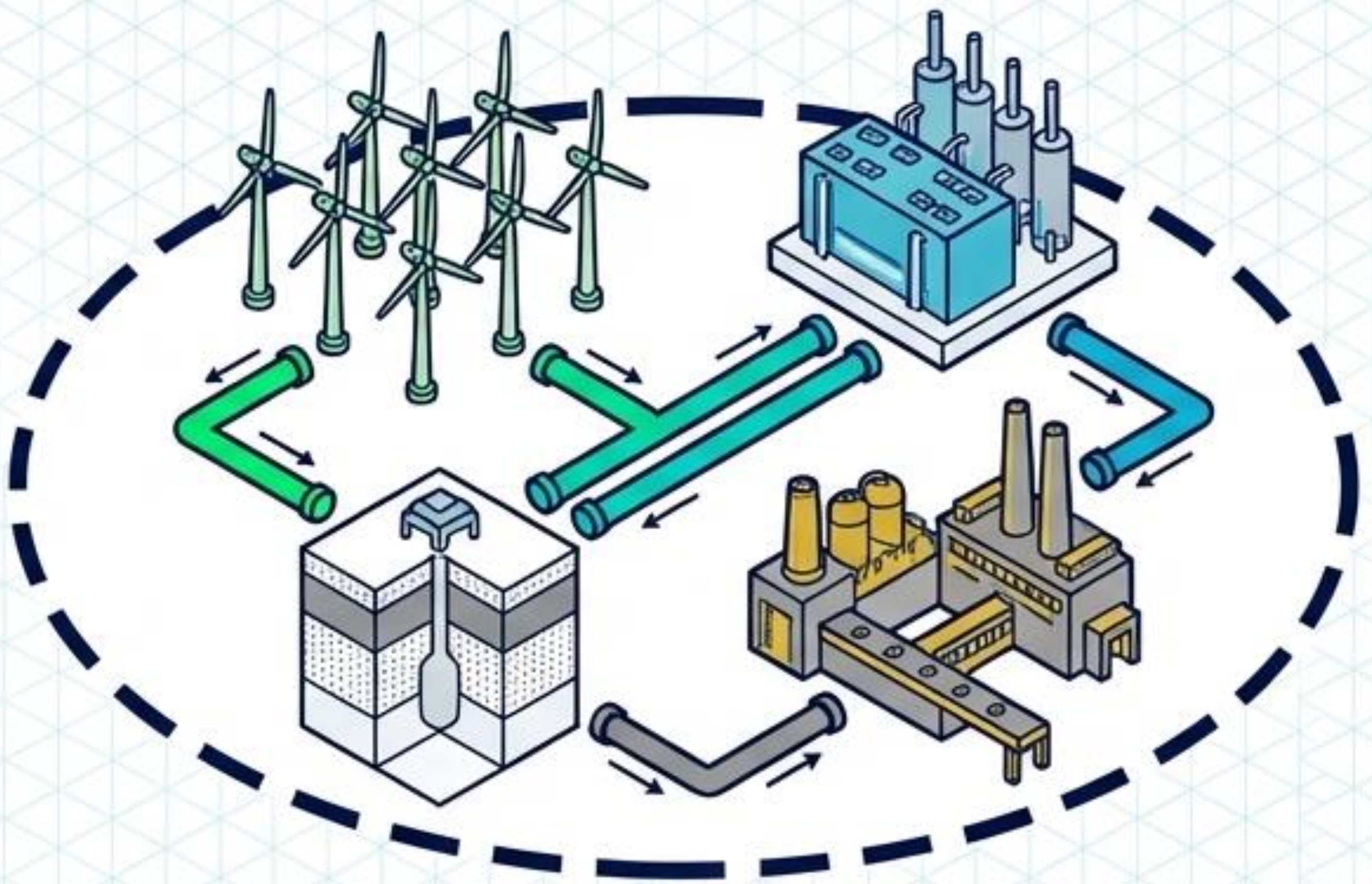
Takeaway: Regions with existing, repurposable gas grids and salt caverns hold a massive, nearly insurmountable infrastructure advantage over pure export models.

The Blueprint Synthesis: Resolving the Deadlock

The Global Commodity Illusion



The Regional Co-Location Blueprint



The near-term hydrogen economy cannot function like the global LNG market. Because moving hydrogen is so inefficient, the winning strategy is Regional Co-location. Demand must be built physically adjacent to supply inside localized industrial clusters.

Strategic Recommendations for the Transition

1

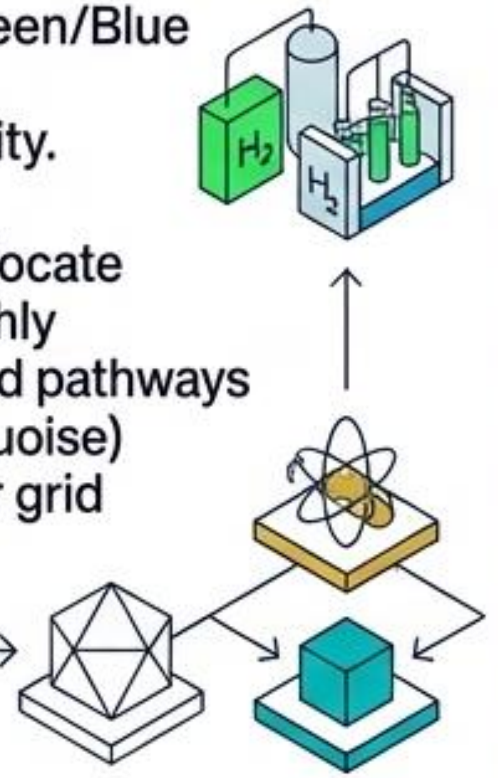
Break the Chicken-and-Egg Deadlock

- Supply-side tax credits (like the U.S. IRA) are insufficient alone.
- Must be paired with aggressive demand creation: mandatory green procurement quotas, carbon pricing, and Contracts for Difference (CfDs).

2

Invest in Portfolios, Not Silver Bullets

- Deploy mature Green/Blue tech now to build operational capacity.
- Simultaneously allocate R&D capital to highly disruptive Wildcard pathways (White/Gold/Turquoise) that bypass power grid bottlenecks.



3

Optimise for the Geography of Infrastructure

- Abandon pure lowest-cost production models if they require oceanic shipping.
- Prioritise project sites based exclusively on proximity to existing pipeline right-of-ways, geological salt storage, and hard-to-abate industrial off-takers.