Hydrogen: Beyond the hype


'Green' N-fertilizer
Green ammonia (NH3)
Green steel
Green methanol (CH_3OH)
Green chemicals
E-fuels / Synfuel

Hydrogen is a bad energy carrier

- **30-40% loss at production via electrolysis**
- **difficult to transport (costly, high losses)**
- **30-40% energy losses at reconversion to electricity**

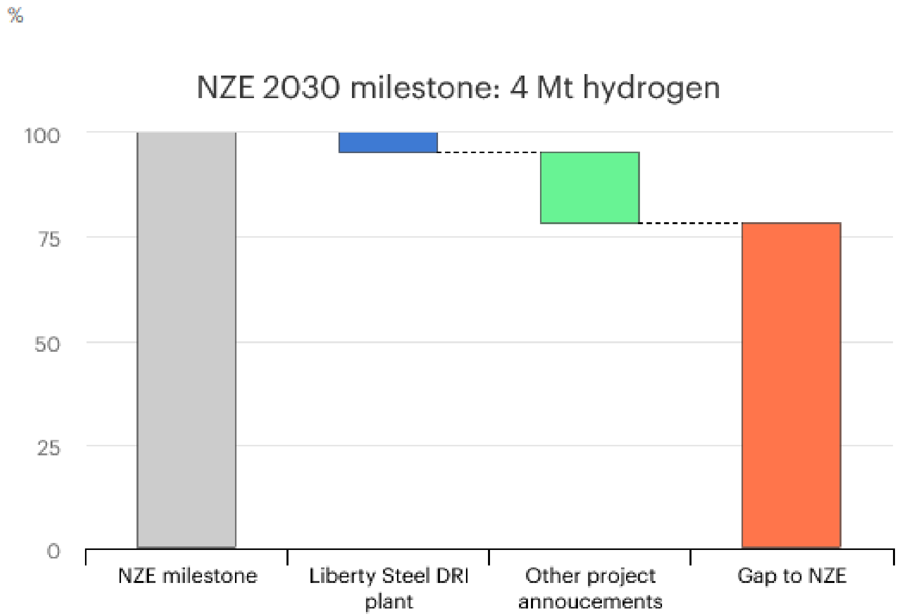
>>> High cost of H2 traded via ships >>> No H2 shipments >>> pipeline H2-trade

>>> international trade by sea only if derivatives are needed, not for H2

Hydrogen is a crucial raw material and reactant

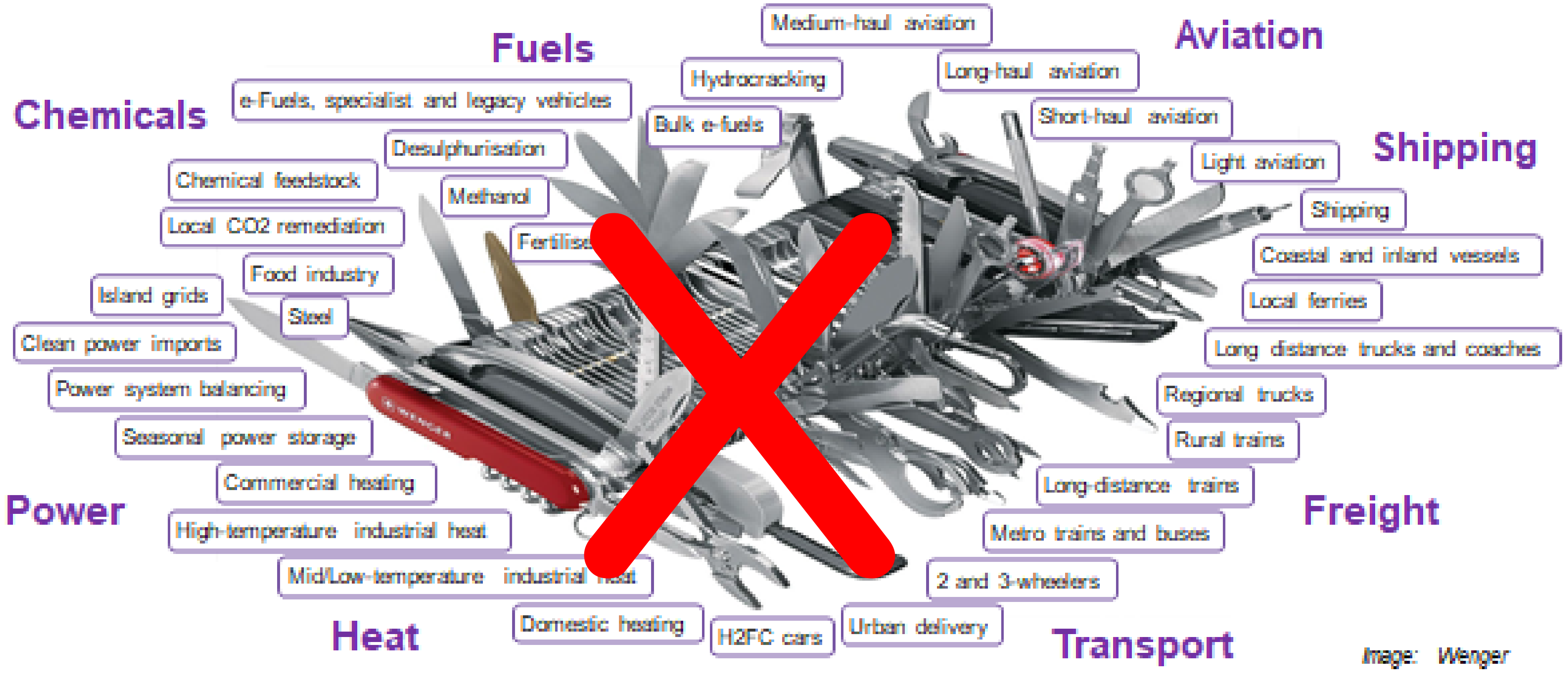
- Steel ~9% of global CO2 emissions
- H2-based DRI is the most mature technology for emission-free steel
- this alone will require the massive upscaling of Green H2 production

Hydrogen demand in the steel sector, Net Zero Scenario and currently announced demonstration projects, 2030

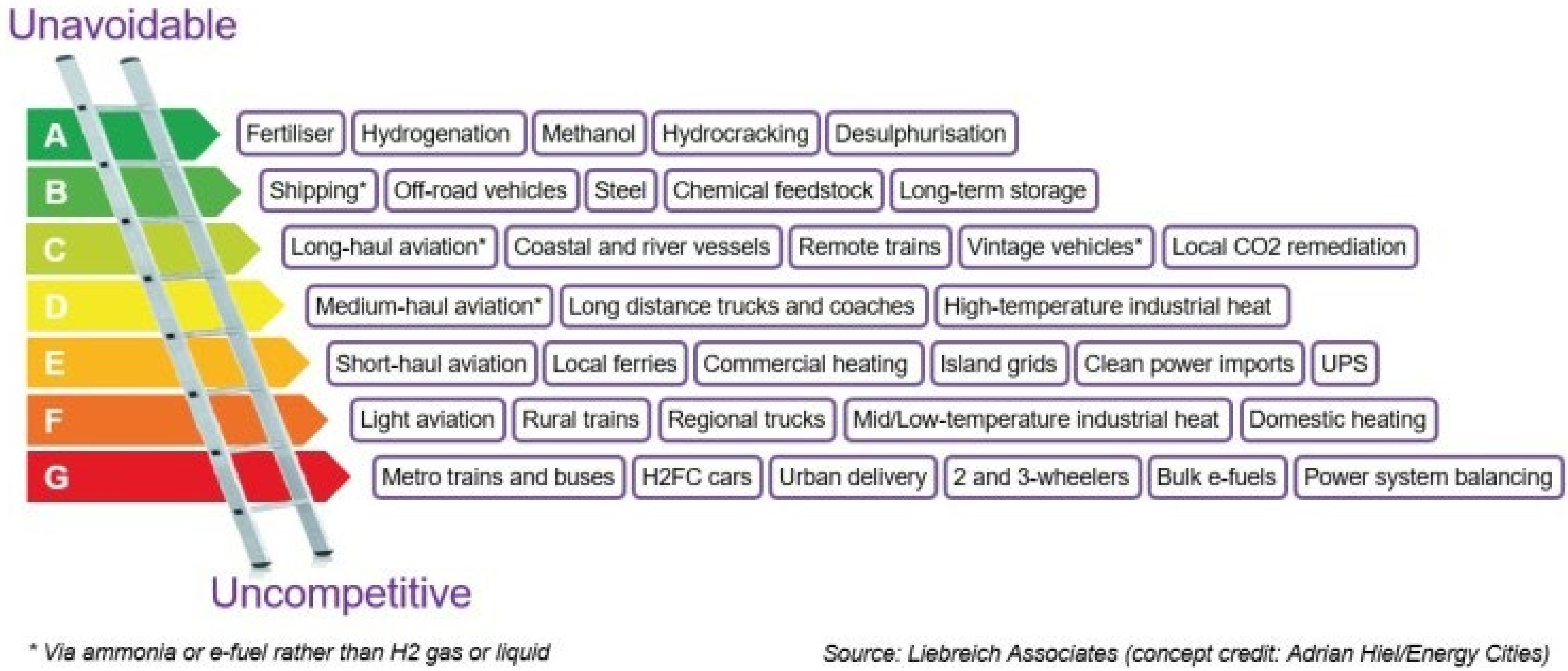


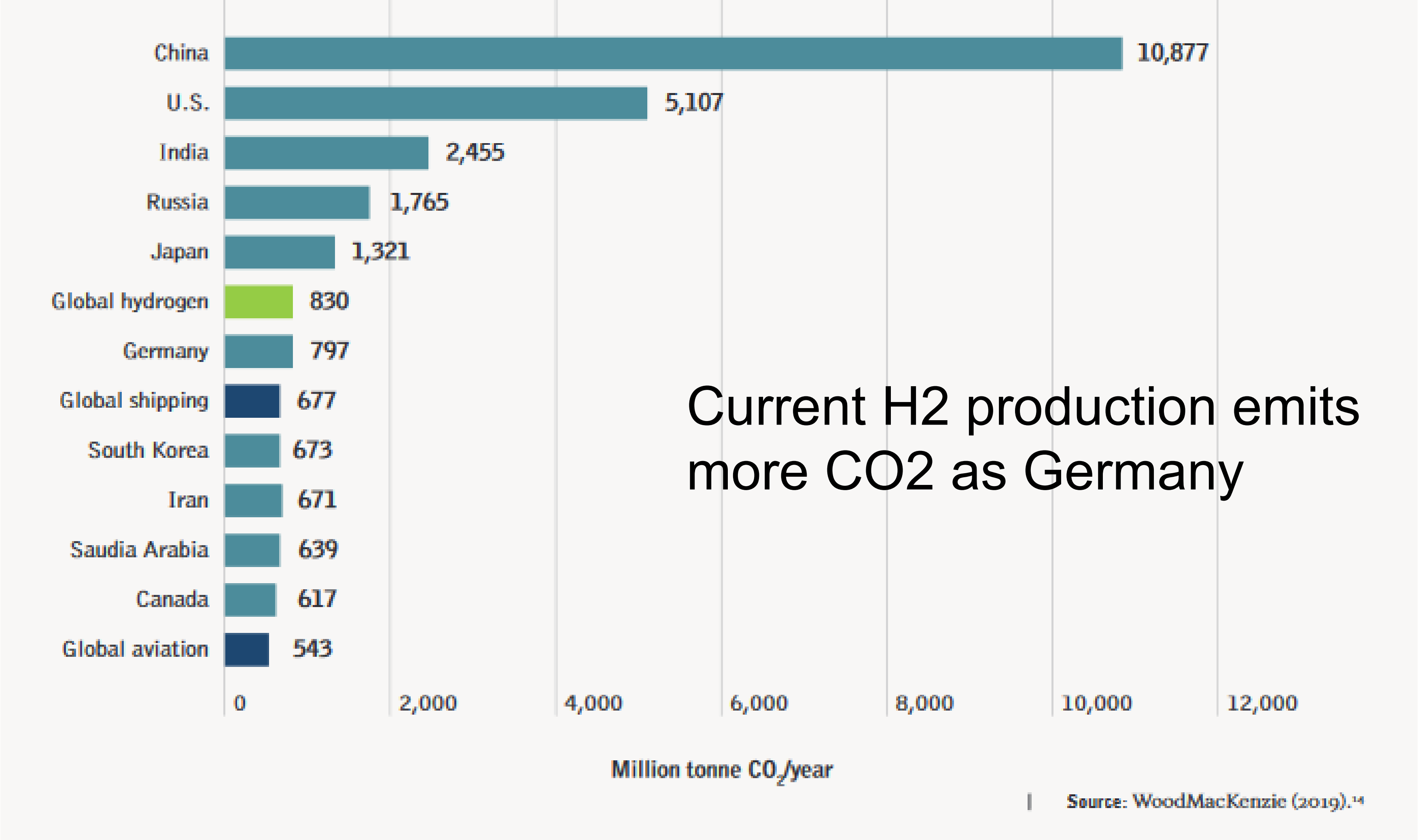
Hydrogen: The Energy Swiss Army Knife

Liebreich Associates



Hydrogen ladder (Michael Liebreich)





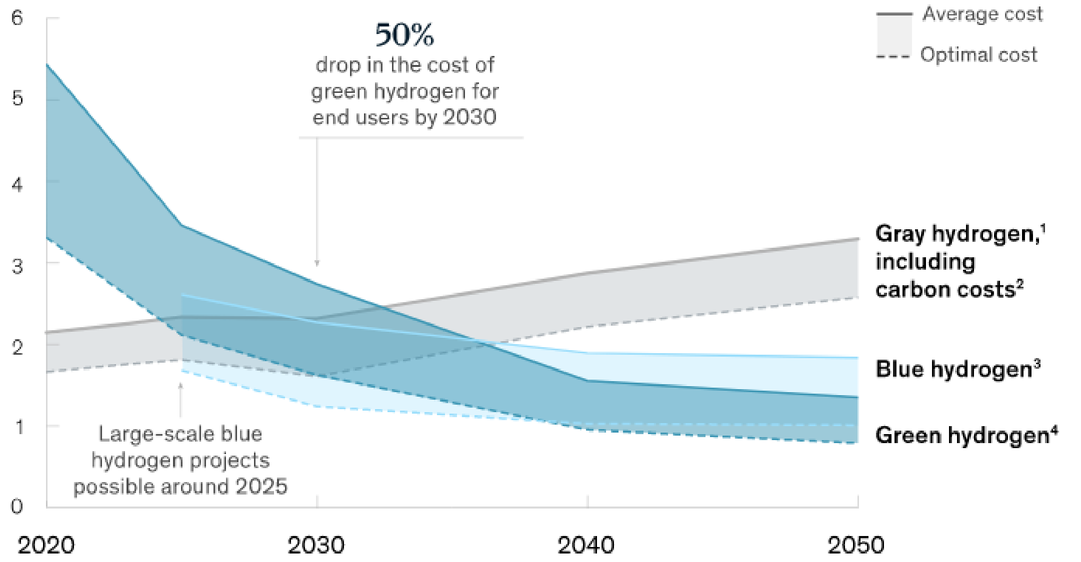
Current H2 production emits more CO2 as Germany

Blue hydrogen losing competitiveness

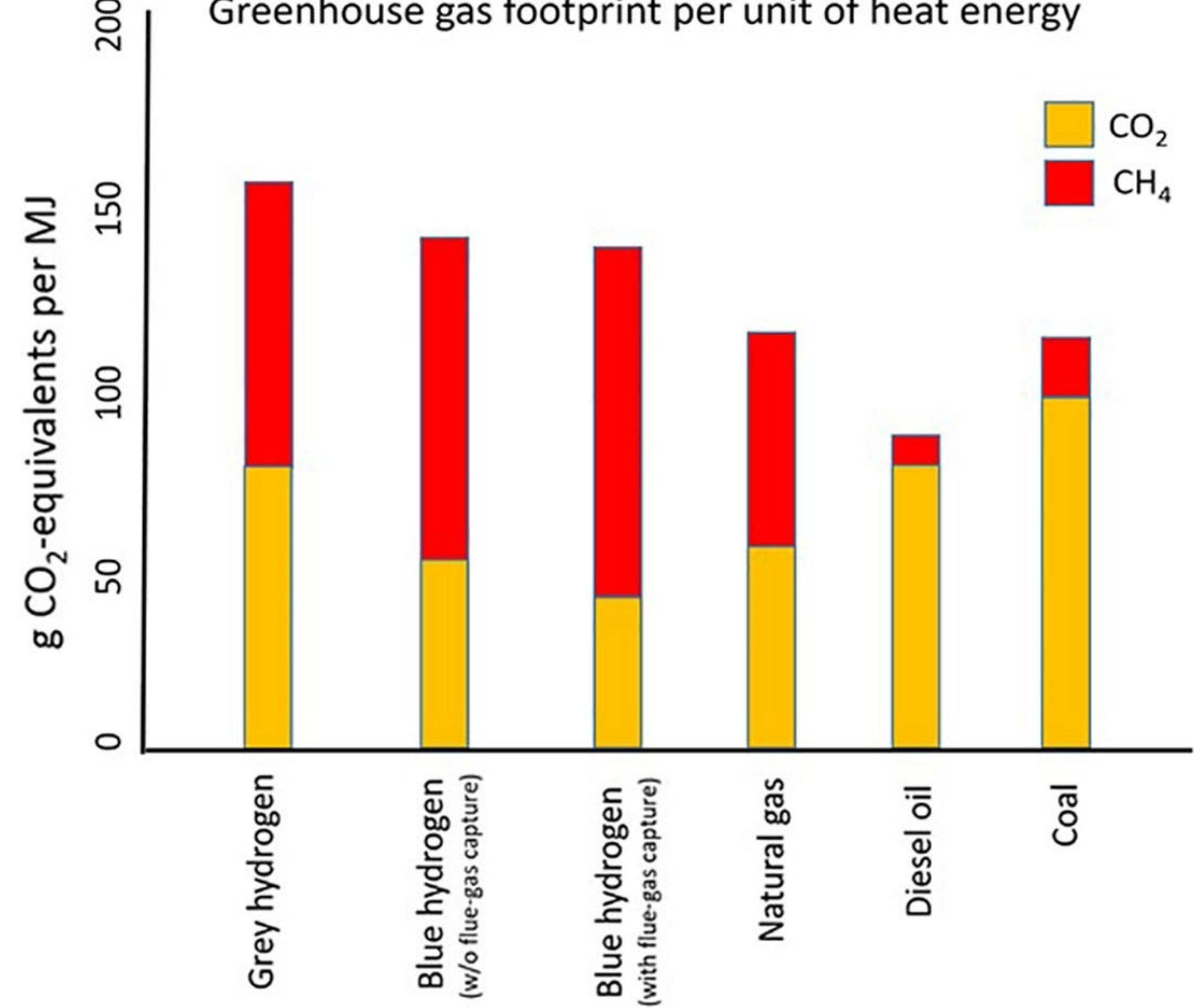
Green hydrogen production costs are expected to fall by approximately 50 percent by 2030.

Forecast as of September 2022

Projected global production cost of hydrogen, $/kilogram



[1]Steam methane reforming (SMR) without carbon capture, utilization, and storage (CCUS).
[2]Based on projected average global CO_2 costs of $57/ton (2030), $94/ton (2040), and $131/ton (2050). For Saudi Arabia, CO_2 costs are assumed to be $33/ton in 2030, $69/ton in 2040, and $105/ton in 2050.
[3]Gas prices of $2.60 to $6.80/MMBtu (approximately $3/MMBtu in Saudi Arabia).
[4]Refers to the cheapest green hydrogen, which is provided by solar energy.
Source: McKinsey Hydrogen & Derivatives Flows Model, October 2022



Blue hydrogen may be more polluting than pure natural gas

Energy Science & Engineering
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MODELLING AND ANALYSIS | Open Access

How green is blue hydrogen?

Robert W. Howarth, Mark Z. Jacobson

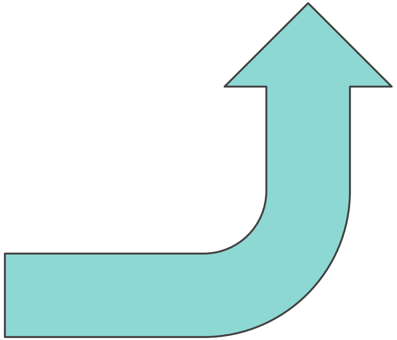
First published: 12 August 2021 | https://doi.org/10.1002/ese3.956 | Citations: 16

A necessity, a hype and a risk

- Hydrogen and derivatives are **necessary for the decarbonisation of "hard to abate" sectors like heavy industry, fertilizer, aviation, shipping**, etc.
- Fossil gas industry sees Hydrogen as an opportunity to justify new gas infrastructure ("hydrogen ready") to increase Lock-In
- Conversion of electricity into H2 means losing 1/3 of energy content. **Using hydrogen where electricity could be used directly will delay the achievement of 100% green energy.**
- Green H2 = "champagne of the energy transition": it **must be used only where the direct use of green electricity is not possible**

Production

- **Scale up green H2** rapidly but sustainably
- Avoid other colours of H2



Use

- **Focus** on essential, unavoidable end uses, not passenger cars, trucks, buses
- **Replace** fossil fuels, avoid rebound effects (flying taxis, space travel)
- Avoid greenwashing of fossil infrastructure

H2 for export in developing countries: A risk and an opportunity

- Unless its production is guided by clear sustainability and developmental strategies, **the expansion of large scale hydrogen production may have significant negative effects**
- Without a clear industrial strategy, it might just be a lost opportunity to reap benefits from green industrialisation
- The expansion of investment and trade in green energy/hydrogen must therefore be shaped by national policies and standards

How does large -scale green hydrogen production look like?

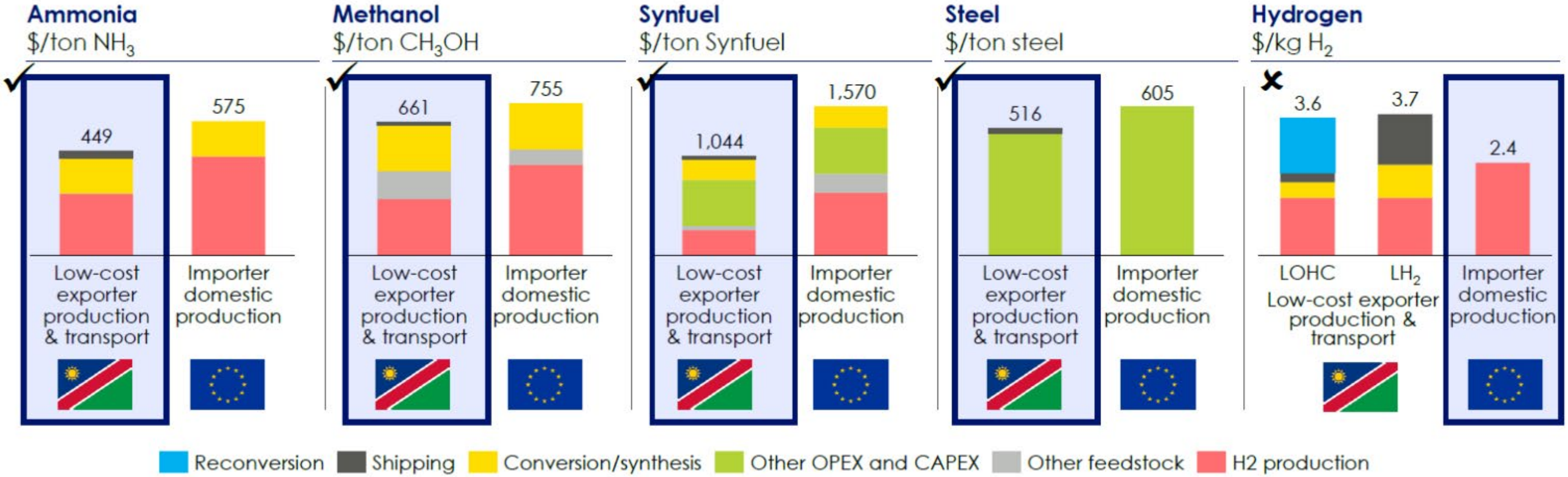
What could go wrong

- Large-scale renewable energy world require huge amount of land. Will pastoralists and smallholders with insecure tenure be displaced by such facilities?
- Electrolysis of water for hydrogen requires a lot of water. Competition for water resources and unsustainable groundwater withdrawal?
- Damage to biodiversity?
- Lack of energy, economic and job benefits for local population
- Lack of domestic value chain and industrial development

PRODUCTS / CHEMICALS MADE WITH LOW-COST HYDROGEN ARE COMPETITIVE VS. DOMESTIC PRODUCTION IN 'IMPORTER' COUNTRIES; HYDROGEN AS A GAS / LIQUID IS NOT

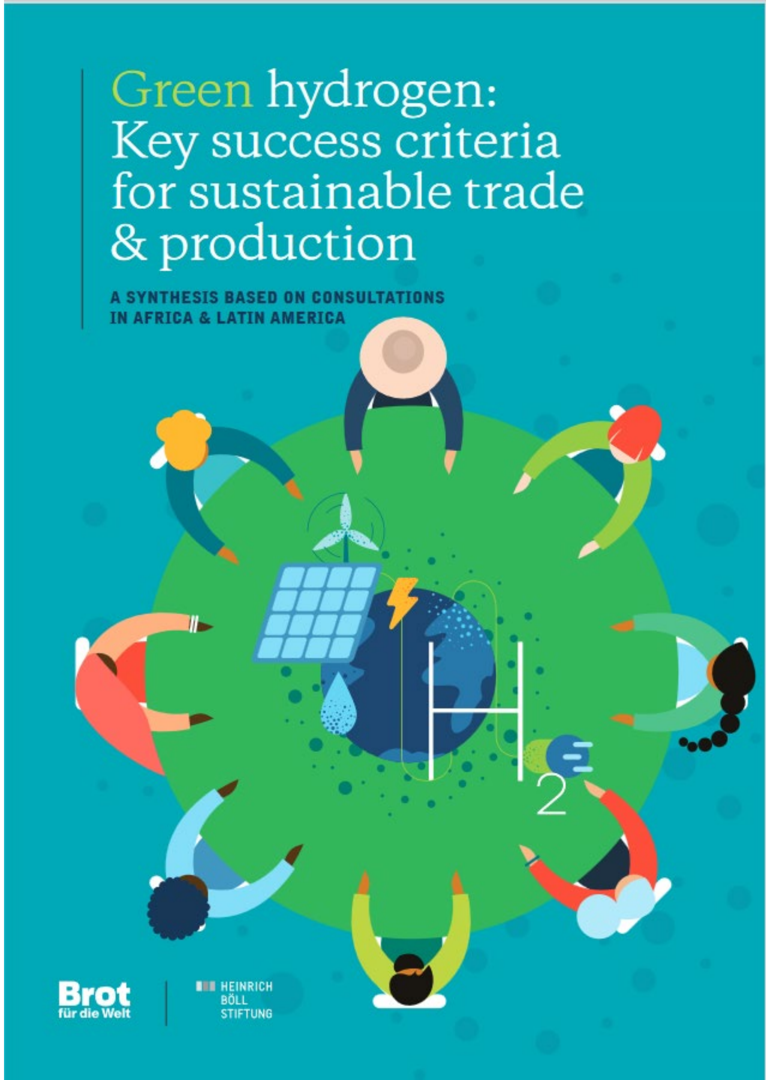
'Delivered cost' of product in importer countries (e.g., EU), 2030

All products are the 'green' version



- Where the **end-use is a product that can ship at low-cost**, (e.g., ammonia, methanol, synfuel, steel) **international trade is competitive**
- Where the **end-use is H_2, production cost advantage is eroded** by conversion and re-conversion – only expected to play a role once **space constraints create production issues** in importer countries (e.g., Japan, Germany, Netherlands, Belgium); **2035+ market**

All costs are for year 2030. H_2 productions costs for Western European Countries. Methanol from Namibia uses DAC for CO_2 at a price of $100/ton CO_2 and in-country supply uses point-source CO_2 at a price of $55/t CO_2. For Synfuel the source of carbon in Namibia is BECCS and the source for EU is point source. The technology is SOEC + FET. The synthesis costs of synfuel represents the CAPEX for the corresponding technology. The H_2 production costs includes all OPEX costs for the corresponding technology. WEF (2020), Clean skies tomorrow. UNCTAD. Mission Possible Partnership (2021). *Net Zero Steel, Sector transition strategy.*



Read more

https://www.boell.de/en/green-hydrogen

Country consultations & Global Synthesis

- **7 Countries:** Argentina, Brazil, Chile, Colombia, Morocco, South Africa, Tunisia
- **Broad set of stakeholders:** local/indigenous communities, social/environmental NGOs, trade unions, international climate and energy experts, think tanks, government officials….
- **Slightly different methods** by each country to get stakeholders' inputs and elaborate conclusions, capturing results into a Country Outcome Document.
- **Country Outcome Documents** were synthesised into one **Global Synthesis Report**

key recommendations from the consultations:

- H2 production needs to be **embedded in a country's overall development, energy and trade plans,** in line with the goals of the UN Agenda 2030. For hydrogen trade to be useful to all, **embed it in an overall inclusive energy transition process, using a systemic approach.** H2 roadmaps and national/regional strategies, including as part of a country's NDC, are a necessary step to provide a long-term vision for green hydrogen.

- Such strategies need to be based on **strong social & sustainability standards**, including respect for human rights & a "do no harm" principle regarding the environment and local communities. They need to**:** generate economic prosperity, promote social inclusion and cohesion, ensure public acceptance and multi-stakeholder participation, promote good governance and transparency and not harm the environment.

Key recommendations to ensure producer countries benefit beyond revenue creation

- **As an overarching principle, green hydrogen** policies need to be shaped in such a way that producer countries do not just remain exporters of raw hydrogen, but benefit from value creation along the full value chain of production and trade. Exporting countries should therefore consider how to leverage external demand and the corresponding revenue and investment to "bootstrap" renewable energy and hydrogen production for domestic purposes.
- **Consumer countries**, for their part, must consider what trade and investment arrangements would support this principle. This is not only a social justice imperative, but one that is logistically preferable, given that green hydrogen derivatives are easier to transport than raw green hydrogen products.

To ensure environmental benefits

- Monitoring requirements and control mechanisms to **prevent leakage from H_2 pipelines**.
- The **carbon footprint** of hydrogen and its derivatives must be certified throughout its entire value chain.
- Minimise **water use**, ensure water supply is not endangered and carry out potential desalination cleanly, with additional water for local communities.
- Careful **spatial planning** for installations is key, with solid strategic and specific **impact assessme**nts and coordination with local communities; biodiversity rich areas must be avoided as sites for green hydrogen facilities.
- **Resource use needs to be minimised** and recycling, in particular of rare materials, promoted.

To ensure social benefits

- **Governance and citizen participation - democratising the energy debate and involve local populations for a fair**, transparent and sustainable energy transition - inclusion increases acceptance.
- **Promote community involvement** from the very design of the project including ensuring that land-using communities have legal support to negotiate with energy companies and access to independent mediation in case of conflict. The principle of **free, prior, and informed consent** (FPIC) needs to be respected for all affected populations.
- No **expropriation or delocalisation/removal of local communities. Promote synergistic uses of land** to avoid land use conflicts, e.g. for solar, use agro-voltaics.
- **Skills training** for the local communities needs to be provided so that they also can obtain the new jobs created. These jobs need to be **fairly paid and safe.**
- **Ensure that hydrogen projects contribute to energy access and overcoming energy poverty** by making parts of the additional renewable energy/hydrogen generation available to the local population (additionality issue)
- **Importing countries should require their procurement and certification frameworks** for green hydrogen include international human rights, social (and environmental) standards.

Special reports

- Pastoralism and large scale renewable energy
- Technical Background Paper
- Popular Education Paper
- Policy Instruments

https://www.boell.de/en/green-hydrogen