POST-HYPE REALISM: WHICH ECONOMICALLY SUSTAINABLE ROLES NOW FOR ELECTROLYTIC HYDROGEN AND E-FUELS?

In IEA´s 2019 Future of Hydrogen report, CAPEX assumptions for installed electrolysers were 900 USD/kW for 2019, 700 USD/kW for 2030 and 450 USD/kW for 2050. Inspired in part by the rapid cost declines observed for wind and solar electricity, many companies and governments made very optimistic deployment plans for electrolysers, hydrogen and e-fuels. However, things evolved quite differently. In IEA´s Global Hydrogen Review 2025 published last month, the median CAPEX figure (outside China), was 2400 USD/kW for 2024 and 1300 USD/kW for 2030. Even adjusting by the 6 years's 27% cumulative inflation, this key figure had increased by a solid 2.5 times.

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The hydrogen bubble´s deflation

That underestimation, largely caused by the neglection of costs besides electrolyser´s stacks (balance of plant, engineering, construction) was only one of several overlooked unpleasant hydrogen "realities". Being the lightest of molecules, its transport, storage and handling at any stage are always complex and costly. Powering electrolysers with intermittent renewable electricity adds further hurdles that contributed to reduce efficiencies, increase the costs and deflate the hype.

As a result, many announced projects have been abandoned, and a natural selection of economically relevant markets for clean hydrogen took place. For road transport, battery electric cars have largely won the race, because of their 2.5 times better power-to-wheel efficiency. Direct electrification also dominated residential heating, and hydrogen blending in gas networks has lost most credibility. In general, distributed and small-scale uses of hydrogen have proven largely uncompetitive, due to the need for expensive and missing infrastructures.

Resilient roles for decarbonizing chemicals, steel, shipping, aviation

On the other hand, hydrogen and e-fuels have consolidated their relevance to decarbonize heavy industry and long-range transport, both sectors that can hardly be electrified directly. Oil refineries, today the largest hydrogen consumers, are now an important source of demand for clean hydrogen.

Most importantly, the production of base chemicals (ammonia and methanol) and steel, are the major share of clean hydrogen projects having reached FID (1.6 Mt H2 by 2030). Methanol and ammonia are also being importantly considered as alternative fuels to decarbonize shipping, while aviation is increasingly pulling demand for e-kerosene.

Table 1 presents a rough illustrative picture of possible future demand for clean hydrogen, with assumptions resembling IEA´s Net Zero scenario:

30% of current refining

100% of ammonia production

30% of shipping switching to ammonia

50 % of primary steel (600 Mt) switching to hydrogen-based direct reduction,

100% of methanol production (for chemicals and shipping),

50 % 50% of aviation switching to e-kerosene,

where for methanol and kerosene, similar volumes would be produced from bioenergy. In total, this rough scenario would create demand for 200 Mt of clean hydrogen, a large part of which could be electrolytic.

	refining	e-NH3	e-NH3 (ship)	steel	e-methanol	e-kerosene
Demand X (EJ)	-	3.4	3	-	2	6
Demand X (Mt)	-	180	160	600	100	140
kg H2/kg X	-	0.18	0.18	0.08	0.19	0.44
Demand H2 (Mt)	12	32	28	48	19	61

Table 1:
Possible long-term global demand for clean H2 from major relevant sectors. Source: author's guess.

Demand creation is the key enabler – and sustainable carbon a major emerging bottleneck

In general, P-to-X products are not expected to be cost-competitive against their fossil counterparts, presenting a substantial "green premium" (often +50% to +500%), even in the presence of carbon pricing. It thus appears increasingly crucial for the climate transition that policy drive (e.g. public procurement, subsidies, quotas of incorporation) and private offtake agreements, especially via "lead markets", having higher ability to pay more, are deployed in synergy.

One example of successful demand consolidation is Swedish Stegra, now building the largest electrolyser in Europe (700 MW), thanks to the voluntary commitments of several car manufacturers to purchase their green steel from 2026. Carbon pricing, and other major regulations, such as the IMO Net Zero Framework expected this October, or the EU's REFuelEU and FuelEU Maritime, are key policy drivers of demand creation.

A major bottleneck, however, is the availability of biomass (especially of second generation, i.e., based on residues and wastes), which is the only affordable source today of sustainable carbon for the production of methanol, e-kerosene, etc., as direct carbon capture is still prohibitively expensive. For example, while 60 methanol-powered large ships are already in the water, and 300 more coming, orders are already slowing down due to insufficient foreseeable low carbon methanol supply. This topic could well deserve closer scrutiny rapidly to allow shaping of viable investments and strategies.