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The Hydrogen Complex

Hydrogen's green production race

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This is the second in our three-part series looking at hydrogen as an energy vector in a net-zero future.

There are grand plans for clean hydrogen and global trade is likely to be a key facilitator, but not just yet.

Hydrogen is not a new molecule in the energy system – globally we already produce around 70 million tonnes of pure hydrogen per year and that production accounts for 6% of global gas use.

The IEA also expects demand for pure hydrogen to double by 2040 due to decarbonisation of hard-to-abate sectors such as transport.

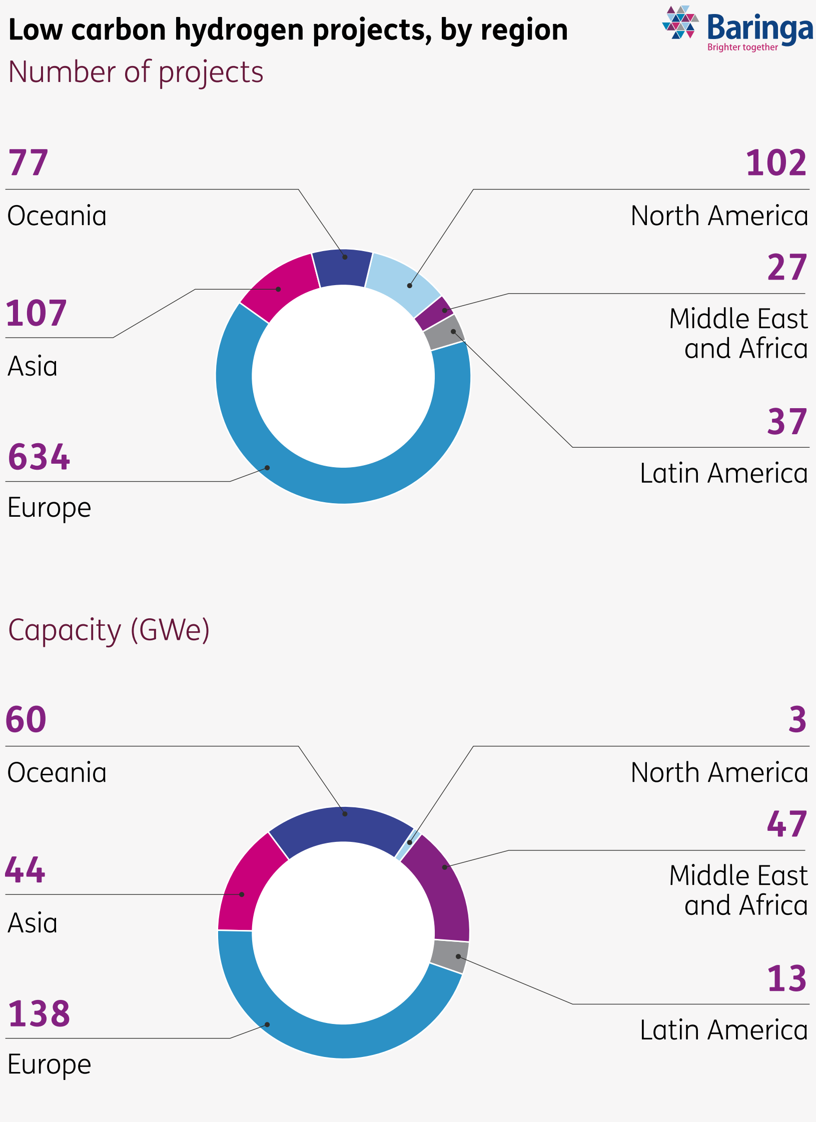
So where is this new supply of hydrogen coming from?

Europe is betting on hydrogen in a big way and the EU has put serious financial backing behind its 2030 40GW green hydrogen production target. Given that the largest electrolyser in operation at the time of writing is 20MW (Bécancour, Québec) (and given that a GW is a thousand times larger than a MW), we are talking a radical increase in planned capacity.

Assuming that the EU intends to run 40GW of electrolysis with electricity from new renewables projects and a capacity factor of 40% (which is easily achievable with offshore wind), Member States will need to build 100GW of dedicated renewable generation by 2030 – that's on top of the renewables required to decarbonise the electricity sectors.

It's difficult to say whether such ambitions will result in a pot of gold at the end of the rainbow or just some widely missed targets, but for those countries where renewable energy potential is limited, there is another way: if you can't make it, buy it.

Low carbon hydrogen projects, by region



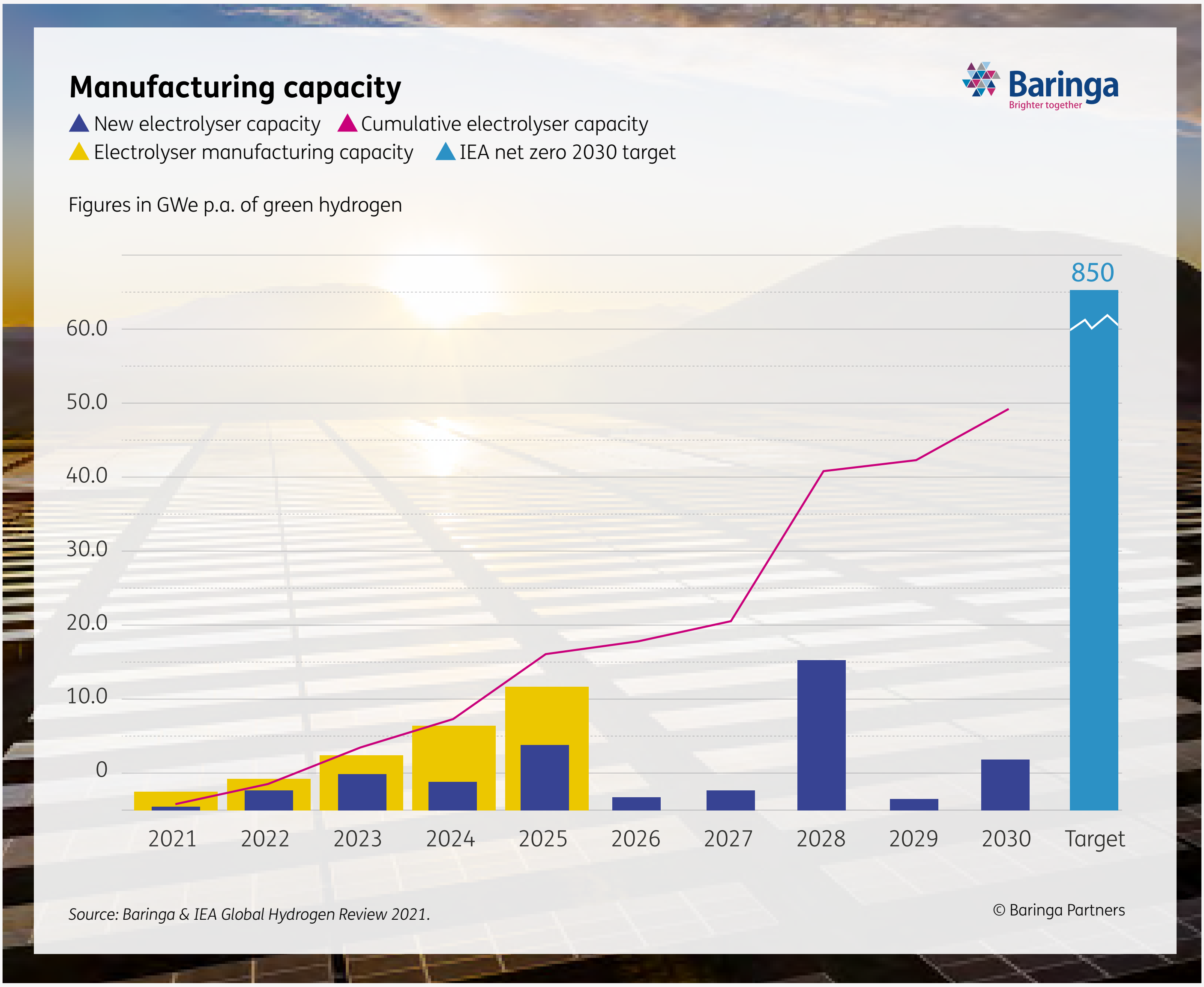
Source: IEA Global Hydrogen Review 2021

Global hydrogen trade

Those with abundant renewable energy resources, such as Australia, Chile, Spain and North Africa are already positioning themselves as green hydrogen exporters, while geographies with sustainable ambitions but limited renewables opportunities could be net-importers. For example Japan and South Korea are exploring alliances to import green hydrogen for road transport – and not just heavy vehicles but cars too.

Another potentially important, and often overlooked, region for green and blue hydrogen production is the Middle East. In 2020, Saudi Arabia committed $5bn to the world's largest hydrogen facility, a 4GW plant using renewable solar and wind power, that will supply overseas ammonia markets (as well as its own petrochemicals industry). Other countries in the region, including Abu Dhabi, are also eyeing hydrogen as a way to monetise their rich solar resource, and as a new route-to-market for their gas developments.

From this and other experiences, our expectation is for the emergence of a fungible global market for hydrogen within the next 20 years.



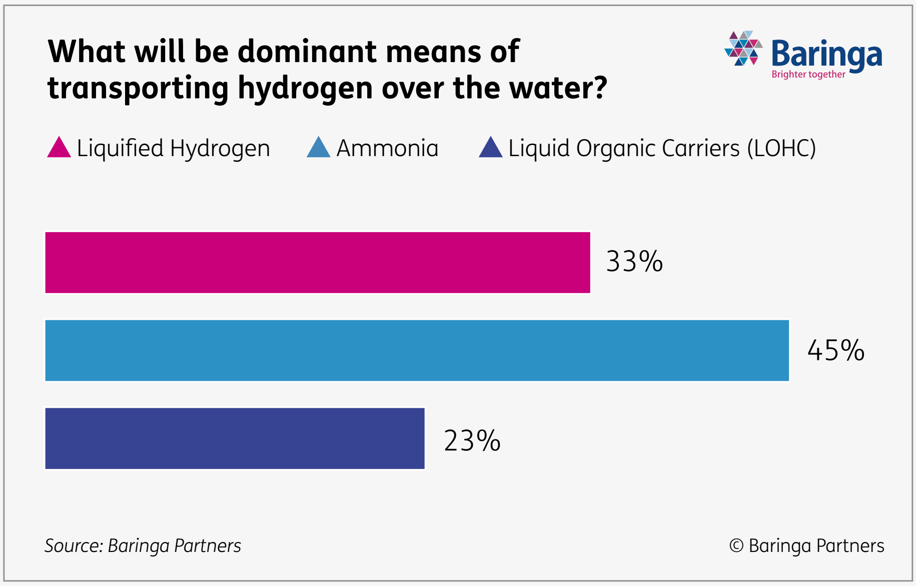
Transporting hydrogen

The prospect of global trade in hydrogen raises a technological challenge.

Today, all hydrogen is transported either by dedicated pipeline or in pressurised steel tubes on the backs of lorries for shorter distances. However, among hydrogen's less favourable qualities is its low volumetric energy density (natural gas has 3x as much energy for the same volume). That means it needs to be made denser in order to move it long distances efficiently. But making it dense is difficult.

Hydrogen has an extremely low liquefaction temperature (-253°C – a mere 20 degrees above Absolute Zero and around 90°C colder than LNG at-162°C). Hydrogen liquefaction processes do not exist today at commercial scale – nor may they ever given the likely costs associated with liquefaction.

Today the equivalent of 5% of the energy content of LNG is used in the liquefaction process. In contrast, energy consumption in liquefying Hydrogen could be higher than 40% given the gas's properties described above, which could blow the economics out of the water when stacked against the alternatives.



Another solution could be chemical combinations – and there are many organisations exploring the technical and commercial opportunities associated with these hydrogen carriers today. These include using ammonia, synthetic fuels or liquidorganic hydrogen carriers (LOHCs).

The jury is out on which hydrogen carrier will dominate international trade in hydrogen but today ammonia has the most bandwidth, as confirmed by our poll of more than 130 energy professionals.

The Haber-Bosch process for producing ammonia from hydrogen is well established and ammonia is a commodity that is traded globally today. However it's worth noting that large scale facilities to decompose ("crack") ammonia to produce high purity hydrogen do not exist today. The cracking process also requires a significant amount of electricity which, in order to be zero carbon, needs to come from... zero carbon sources such as renewables! Nothing with this simplest of elements turns out to be straightforward.

In the final part in our series, we will look at the applications and cost-competitiveness of clean hydrogen across geographies and specific use-cases, and the types of private and public support required to make it an economically viable alternative to fossil fuels.

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Baringa Partners

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