Hunting hydrogen: who's leading the race for green hydrogen leadership

Green hydrogen | As green hydrogen starts to gain a foothold in the decarbonisation journey, Alice Grundy looks at the more developed markets for the technology, the measures needed to scale further and the role of solar PV

Green hydrogen, despite its undeniable role in a net zero economy, remains a nascent technology and one which has sparked many a debate. Whilst it's not controversial to say it will be needed in some capacity, the extent to which it will be used as the world decarbonises - and in which sectors and specific use cases it is applied - is less of a clear cut picture.

Green hydrogen can help to power fuel-cell vehicles and is often thought to be best paired with shipping and freight land vehicles and aviation. It can also be used for a wide variety of industrial purposes - with industry being tipped as the main customer for green hydrogen - as well as for heating. In particular, it is seen as beneficial for energy intensive industries such as the ceramic industry, the steel industry and the cement industry.

Green hydrogen is produced through electrolysis, during which an electrical current is used to separate hydrogen from the oxygen in water. This electrical current is sourced from renewable generators, typically – though not exclusively – solar and wind. Green hydrogen differs from other forms of hydrogen due to it being produced using renewables, although blue hydrogen – which is produced from hydrocarbons but incorporates carbon capture and storage (CCS) – is also carbon neutral.

In the race for green hydrogen leadership, three markets have surged ahead. These – Europe, Australia and the Middle East – have benefitted from either favourable policy environments, large project commitments or a combination of the two. But how exactly has this been achieved, and how does solar play into this?

Building a success story for solar and green hydrogen

There are a number of examples of green hydrogen projects that include solar around the world. In Scotland, solar is to be paired with a 10MW electrolyser and wind power as part of a project run by Iberdrola unit ScottishPower Renewables, gas specialist BOC and ITM Power. In Singapore, the Renewable Energy Integrator Demonstrator has seen a microgrid combining solar with hydrogen, wind, thermal and storage technologies built by Engie and Nanyang Technological University.

Meanwhile, solar giants such as the aforementioned Iberdrola have moved onto the scene, with the Spain-headquartered utility having announced the creation of a new business unit dedicated to green hydrogen in September 2020. It is currently working on a project to be located in Puertollano, southern Spain, which will see 100MW of solar PV combined with a lithium-ion battery and an electrolysis system.

But what makes solar a beneficial technology to provide power to an electrolyser over other forms of renewables? One factor which may influence the pairing of the two is price cannibalisation, which in countries such as Spain and Portugal is making it difficult to push more solar onto the system due to these markets already being heavily saturated with solar. This is something which can be overcome by pairing the solar with an electrolyser and "directly producing hydrogen in hours when the sun is shining" according to Aurora Energy Research's senior commercial manager Alexander Esser.

Esser also suggests that solar will have a higher importance when it comes to green hydrogen production due to import needs, with countries with high demand from industry such as Germany requiring imports from southern countries such as Spain and Portugal. These countries will "play a big role" in producing hydrogen and exporting it to north Europe, which will be a "big upside" for solar due to the high levels seen in those countries.

Imports will not only come from other areas of Europe, however. Australia has joined forces with Germany to fund a feasibility study into the production, storage, transport and use of hydrogen from renewable energy, with the project looking specifically at exporting green hydrogen from Australia to Germany.

Indeed, Australia prides itself on its status as leading on green hydrogen exports. It has signed deals with Japan, South Korea and Singapore, although the Germany partnership is the first to explore exports to a European country. Commenting at the time of this announcement, Australia's energy minister Angus Taylor said Australia has a "natural competitive advantage to be a world leader in exporting hydrogen", with exports from the hydrogen sector expected to contribute an estimated AU$11 billion per year in additional GDP by 2050.

Alongside its import potential, another

Credit: Toshiba

Toshiba's Hydrogen Energy Research Field in Fukushima, Japan, is exploring the use of solar in hydrogen electrolysis.

driver for solar when it comes to green hydrogen will be that there are often site constraints next to the offtakers. Esser suggests the example of a steel mill, stating that in cases like this "it's often easiest to build a solar farm next to the site to then produce the hydrogen", describing this as "the big advantage of co-locating".

However, the benefits of solar are highly location dependent. In desert countries sunshine is predictable and follows a daily pattern, meaning solar can be blessed with a high load factor. In countries such as the UK, solar has a load factor of around 15% compared to offshore wind being able to reach a load factor of 50%, according to Siemens Energy UK & Ireland's head of strategy Matthew Knight, who describes the load factor of the electricity supply as being "the biggest cost driver of hydrogen from electrolysers". The company is involved in the H2Future project in Austria, which has been running since 2017 and has seen a 6MW proton exchange membrane electrolysis system installed at the Voestalpine Liz steel plant, going into commercial operation in 2019.

When it comes to the energy costs, and in particular solar, it still seems to be a little unclear what price it would need to generate at to make it truly viable. Whilst Knight says it should be "as low as possible", he suggests it's "hard to say" a definitive figure.

Christian Pho Duc, Smartenergy's managing director of H2 projects, suggests that €50/MWh was "on the higher side and not sufficient for all cases" and that €30/MWh is around "the benchmark today". However, prices which go below €20/MWh or even €15/MWh are likely to arrive in the next five to ten years. Despite an auction in Portugal that set record lows with prices of €13.9/MWh, "there are no standalone business cases which really work on this price by itself today", he added.

"If you look into it, nobody right now - even with the nice sun of Portugal - can operate with this €13.9," Pho Duc says.

Storage driving hydrogen

For any nascent technology, the big question is how to build a viable business case. Hydrogen has been hyped up in the past says Pho Duc, but was lacking in political will whilst largely suffering from renewable electricity costs remaining too high. As it stands now, the outlook is more positive with strong political commitments from both the EU and Australia, as well as low electricity costs.

Energy storage can also have an impact on the business case, however. Installing a storage system for a green hydrogen project is no different to installing one for a solar PV plant or any other type of generation. The storage system allows excess renewables to be captured and used – in this case to produce green hydrogen – when the sun isn't shining or the wind isn't blowing.

In particular, storage with a duration between 30 minutes and two hours "makes the business case better" because of its ability to overcome those short-term variations in renewables, Pho Duc says. However, whilst long duration battery storage which could reach over days "would be nice", it isn't currently economically viable, he says, with the IRR of the cost of hydrogen getting worse with long duration. With costs continuing to fall, this will become viable in the future, however.

One storage company that deals in longer duration – although not the sort that stretches into days – is Invinity Energy Systems, which is to install a 1.8MWh flow battery on the island of

Eday, Orkney in Scotland, which will combine with tidal power to produce green hydrogen.

Ed Porter, business development director at Invinity, lauds the combination of these technologies as being very complementary, with the nature of tidal requiring a heavy amount of cycling, something which flow can handle.

Describing the interactions between storage and green hydrogen production, Porter says that "the key principle of this is that you're taking intermittent generation in the form of solar or tidal or whatever it may be, and then you're using that to provide a baseload energy supply to the electrolyser," with electrolysers needing "very constant baseload".

Political commitment: Supporting scaling up

The need for green hydrogen production may be understood, but how to scale it up and integrate it into the rest of the energy system is a different question altogether. Much of this is at least somewhat reliant on policy decisions. A number of policy commitments have been made in the past year, most notably the EU's Hydrogen Strategy, which was released in July 2020. A key element of this is a goal of enabling at least 40GW of electrolyser capacity across all of Europe by 2030 and a target of 6GW of electrolysers by 2024.

Aurora Energy Research's Alexander Esser describes this as a "very ambitious target" but warned that it's "not clearly mentioned how those targets should be achieved". In fact, when looking on a country level, the targets of the different European countries individually do not add up to the 40GW outlined by the EU. But the fact hydrogen's role in deep decarbonisation has been acknowledged and commitments made – not only by the EU as a whole but by Germany and Spain among others – is perhaps to be celebrated.

Indeed, Smartenergy's Christian Pho Duc describes the political commitment to hydrogen as "very, very important", with the associated "huge investments" helping to improve investor confidence.

Australia, too, has published a national hydrogen strategy, which was released in 2019. This details its plans to continue to scale the technology and maintain its leadership. Key to Australia's approach is the creation of hydrogen hubs, which are regions where users of hydrogen are co-located in metropolitan, regional and remote areas. An AU$70 million pot has also been designated to help green hydrogen projects in Australia by the Australian Renewable Energy Agency (ARENA), which is an independent agency of the Australian federal government.

Meanwhile, Western Australia is to host to the Asian Renewable Energy Hub, a project focused on green hydrogen production that could eventually reach 26GW of solar and wind generation.

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Approval of the first stage, which includes 5GW of solar and 10GW of wind, was granted in October 2020 and came not long after the Western Australian government announced a AU$22 million investment to boost the state's hydrogen industry across export, use in remotely located industries, blending in natural gas networks and use in fuel cell electric transport vehicles.

Alongside the EU and Australia, the Middle East is seen as leading when it comes to green hydrogen. Saudi Arabia in particular has cemented its position with a commitment to build the world's largest green hydrogen project. It is to be jointly owned by Air Products & Chemicals, ACWA Power and the city of Neom, which is to be a smart city near the border with Jordan. The plant will be powered by 4GW of solar and wind and will produce 650 tonnes of green hydrogen per day.

Other projects include a green hydrogen plant which was installed at the 1GW Mohammed bin Rashid Al Maktoum Solar Park in the United Arab Emirates. This plant is a collaboration between the Dubai Water and Electricity Authority and Siemens and was lauded as the first of its kind in the MENA region.

When it comes to the combination of solar and green hydrogen, the Middle East benefits from having very high solar irradiation and the lowest solar prices in the world. The Middle East also benefits from its experience in dealing with large scale oil, gas and power projects.

However, regardless of policy commitments or large project announcements, the question does turn to how to finance green hydrogen. The Netherlands has a subsidy for the electrolyser itself, whilst in Germany the demand side is being incentivised. In general, it is agreed that subsidies will be needed, with Pho Duc stating that it is "hard to have a business case without additional subsidy", with suggestions for incentives being a transfer of funds or a carbon trading scheme that is beneficial to hydrogen.

Power purchase agreements (PPAs) will also be a key part of green hydrogen production, with Aurora Energy Research's Alexander Esser stating in the case of solar this is due to the need to have "an offtaker for the hydrogen for the solar developer, and the electrolyser producer wanting to have a stable price for the power".

Most importantly, when it comes to green hydrogen, regardless of which country, continent or state we're looking at, the message seems to be that time is of the essence. Green hydrogen may be nascent, but it is "an essential part of the value chain", as Pho Duc says.

"Waiting is not an option," Pho Duc says, with the development time of hydrogen being longer than projects such as solar due to it being a chemical plant. "You need to be prepared once the framework to start the project is in place," he adds.

This was echoed by Siemens Energy's Matthew Knight, who said that the industry needs both speed and scale, with the challenge being building "the first handful of gigawatt projects this year to get the supply chain going".

Green hydrogen is an industry that needs a lot of time, money and political will funnelled into it. It has experienced some big wins on these fronts, but to truly develop the industry so that green hydrogen can be produced – and used – at scale, this must continue, and at pace. Lessons can be learned from the EU, Australia and the Middle East and adopted into other strategies and projects, but it is also important that these three markets, whilst leading now, refuse to rest on their laurels. There's a lot more work to do. ■