Renewable PPAs and a review of the commodity price spike on renewable hydrogen production costs

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The Renewable Energy Directive Recast (RED II), which was carried in the European Parliament's plenary session on 14 September, sets demand-side targets for the use of renewable hydrogen, which, if adopted, will mandate its integration into the existing hydrogen market as well as replacing other hydrocarbon fuels.

The objectives for renewable hydrogen focus on energy demand in two sectors. Firstly, by 2030, 5.7% of all transport fuels produced in the EU will need to be renewable hydrogen based, which includes the use of zero carbon fuels such as renewable ammonia by the maritime sector. And second, by the end of the decade, 50% of all hydrogen used in industry will need to be renewable hydrogen. The two demand-side targets together amount to around 9-10 million tonnes (mt) of renewable hydrogen or equivalent green ammonia use by 2030.

On the supply side, the European Commission's REPowerEU package (May 2022), sets an EU supply-side target of 10mt of renewable hydrogen by 2030. This target therefore aligns with the demand targets indicated within RED II; it is also consistent with the objective of enhancing European energy security, as green hydrogen can replace the use of imported natural gas by industry.

With the objective of supporting price transparency, ICIS has conducted the following analysis which reviews the cost of producing renewable hydrogen, as defined in RED II, based on the use of electrolysis and renewable power purchase agreements (PPAs). The analysis spans the following five European countries: Germany, the Netherlands, Italy, Spain and the UK. Although not bound by RED II, the UK is included due to its future potential as a producer of renewable hydrogen and due to the connectedness of European power and gas markets, meaning it could emerge as a supplier of renewable hydrogen for the EU towards the end of the decade and beyond.

RENEWABLE HYDROGEN AND POWER PURCHASE AGREEMENTS

Renewable hydrogen, often referred to as "green hydrogen", regularly gets discussed in non-specific terms as hydrogen produced using renewable electricity. Over the course of 2022, there have been significant developments at EU policy level on what it means to produce renewable hydrogen. In establishing this framework, European policymakers have provided a clear definition for renewable hydrogen, supplanting ambiguity within the hydrogen market to date.

This is important, as the introduction of a clear policy and regulatory framework is paramount to investor confidence.

ICIS therefore considers renewable hydrogen as the definition set out in RED II for renewable fuels of non-biological origin (RFNBO), which broadly means that:

Hydrogen can be considered renewable if the power supply for its production can be proven to be sourced from a renewable asset. This proof can take two forms. In the first instance, the hydrogen plant (an electrolyser) is directly connected to the renewable asset, only drawing power from that asset and not from the grid; in the second, that the electrolyser takes power from a renewable asset via the grid, but this power is supplied under the terms of a renewable power purchase agreement (PPA).

A PPA is an agreement between a power producer and an offtaker for a set volume of power over a specific period of time. As well as agreeing the volume of power, the producer and offtaker will define the price at which the power is supplied, which will remain constant over the duration of the PPA. In the case of renewable hydrogen, the power must come from a renewable technology (excluding biomass), and under the proposals made by the European Parliament, the power produced from the renewable asset must be used within the same quarter.

This definition must apply to hydrogen produced and used within the EU, as well as hydrogen imports.

Given the lack of hydrogen infrastructure which could be used today to transport hydrogen produced at the site of a renewable asset to a hydrogen offtaker, the likelihood is that grid-based electrolysis production using renewable PPAs will predominate over the alternative of co-located, dedicated power production and electrolysis. This is so that the producer can build an electrolysis plant at the point of demand, and as such will require that the hydrogen producer uses a renewable PPA in order that they may ensure that their hydrogen qualifies as renewable.

Given the weight of renewable PPAs within current EU policy and their likely use in the early stage of development of the hydrogen market, and in the interest of hydrogen price transparency, reviewing market-based PPA data and reflecting this in a final cost of production as a price indicator is seen as an essential first step.

Although cost of production is not a traded price, estimation of a hydrogen project's economics gives the market an indication of the floor at which hydrogen would be priced at in order to support the investment necessary for growth in supply. Equally, during periods of over-supply, the variable cost of hydrogen production would also function as an indicator for minimum market prices.

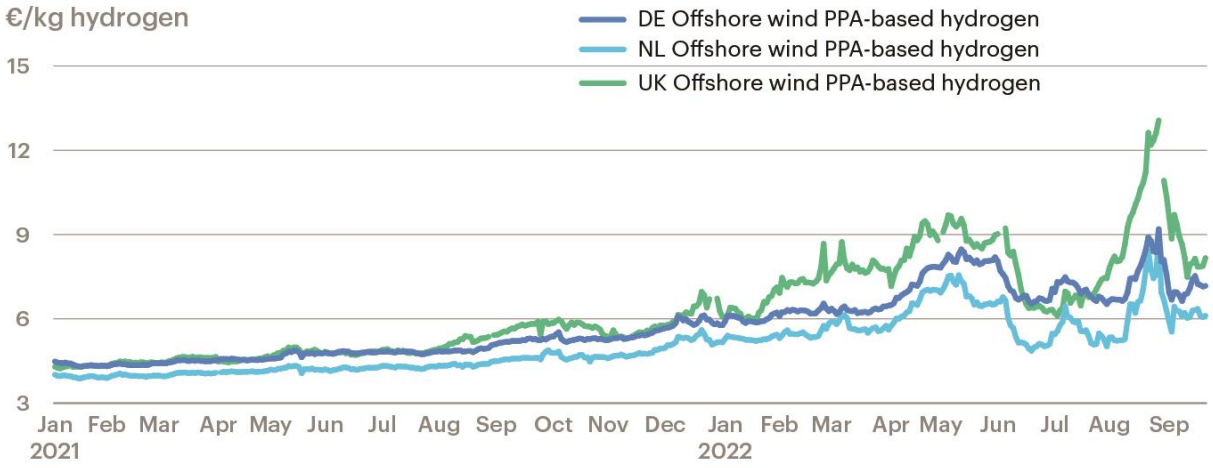
PPA AND THE WHOLESALE POWER MARKET

As well as requiring the use of PPAs for production of hydrogen to qualify as renewable, a fixed price PPA also gives electrolyser project owners clarity on their cost of hydrogen production. By contrast, were a project developer to purchase their power from the wholesale market, they would be exposed to power price volatility which may not be recoverable in the hydrogen market.

The two frameworks, PPA-based and wholesale, for pricing power are not disconnected. In pricing a PPA, the power seller will look to the wholesale power market's forward curve, ensuring that the agreed power price is reflective of the shape of the forward curve over the duration of the PPA, and also taking into account the balance of risk between buyer and seller, in addition to any implied cost of hedging.

With the sharp uptick in near term power market prices over the last 20 months, the price at which PPAs are settled has increased. This trend is clearly visible in the trajectory of ICIS's estimations of renewable hydrogen production costs:

Commodity price spike lifts ICIS PPA-based renewable hydrogen assessments



Source: ICIS

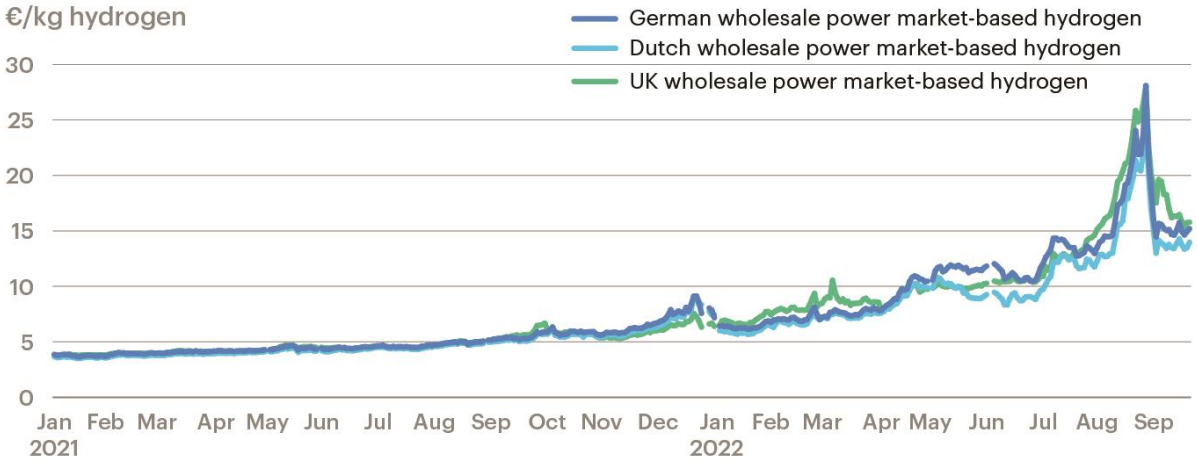
The graph above shows the cost of producing hydrogen based on the ICIS Hourly PPA-based Renewable Hydrogen assessment, reflecting the use of a 10-year offshore wind PPA starting in 2025.

At the beginning of 2021, signing such a PPA would have resulted in production costs of renewable hydrogen (including recovery of capital investment) of around €4-4.50/kg of hydrogen for northwest European countries. By the third quarter of 2022, following the record-breaking escalation in near-term power prices due to fuel supply tightness and infrastructure constraints, signing a PPA for the same tenor, technology and start year would result in production costs in the range of €6.10-8.15/kg of hydrogen, including capital cost recovery.

Looking to the variable cost of hydrogen production, and therefore excluding capital cost recovery, hydrogen production costs under the same PPA type have climbed from €2.30-2.70/kg to €4.40-6.50/kg of hydrogen.

Although there have been evident price spikes to the cost of producing hydrogen using renewable power based on PPA contracted power, the 10-year tenor of the PPA illustrated here means that the prices for the PPAs have a much lower volatility than the prices for power in the wholesale markets.

Year+2 wholesale power market-based hydrogen production costs soar over Q3 2022



Source: ICIS

The above graph shows the ICIS Wholesale Power Market Hydrogen production cost, which reflects using wholesale power for calendar year 2025. As shown, production costs based on an electrolyser purchasing electricity supply from the wholesale power market and achieving a return on capital

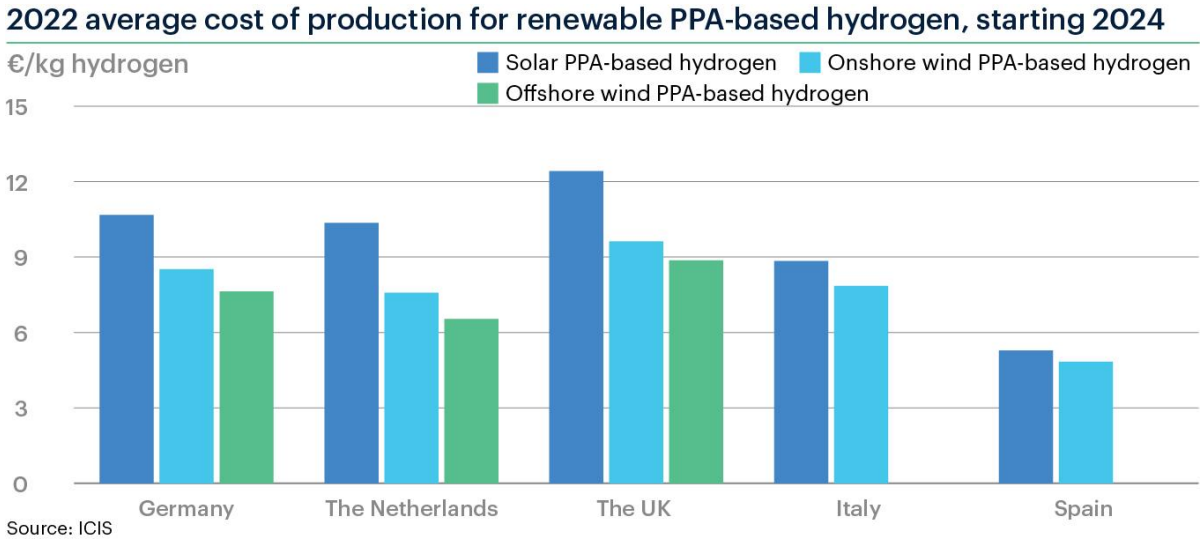
have greatly exceeded those based on a contemporaneous renewable PPA, with the peak of €28/kg of hydrogen during late August – more than double that of the ICIS Hourly PPA-based Renewable Hydrogen assessments shown for 10-year offshore wind.

While this comparison appears to favour renewable PPA-based production over wholesale priced power purchase, the two price charts depict two very different project types. Under the renewable PPA-based project type, the power price is spread over a much longer period of time, reflecting the current backwardation along the far curve, whereas wholesale power market-based hydrogen reflects a project that is willing to bear price risk in expectation that power prices in the future will fall back from today's levels as the market for power renormalises. In the future, were a spot market for hydrogen to emerge, parallels with other markets would expect such prices to be related to the near-term spot power price and for the hydrogen producer using PPA priced power potentially carrying greater risk.

TECHNOLOGY AND GEOGRAPHY COMPARISON

To review which power generation technology produces the lowest-cost hydrogen, ICIS has taken an average of the PPA-based assessments over 2022 for each technology type and reviewed two scenarios. Firstly, when accounting for capital cost recovery, as shown from the graph below.

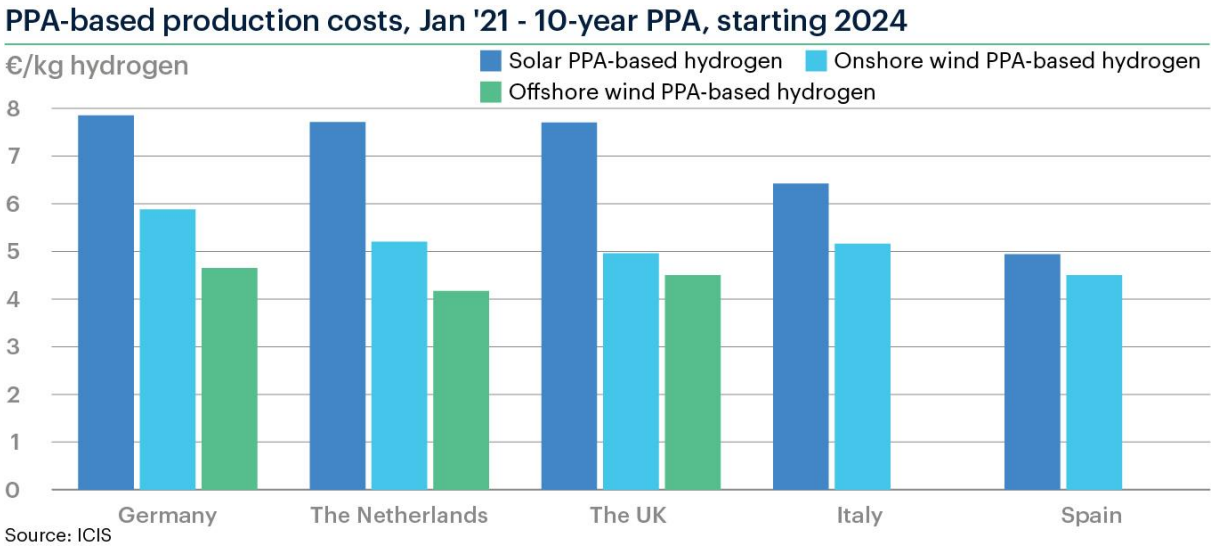
For the technology comparison, ICIS has used its Hourly PPA-based hydrogen assessment data, which reflects a PPA whereby the power is provided to the electrolyser asset as it is generated, reflecting immediate temporal balancing.



As shown from the graph above, wind-based PPAs result in lower production costs when accounting for capital cost recovery when compared to solar. This is because both onshore and offshore wind would likely result in more hours of generation per year than solar, creating a greater production base over which to spread the income required to cover the capital investment and fixed operating costs.

Out of the five countries reviewed, the above graph also shows which have carried the lowest cost of production. Due to the price cap to Spanish wholesale power markets, Spain has reflected the cheapest cost of production on a capital cost recovery basis, with production costs averaging €5.28/kg for solar and €4.85/kg for onshore wind.

At the start of 2021, Spanish onshore wind and solar-based hydrogen production costs were still some of the cheapest production methods for renewable hydrogen according to ICIS data.



Even given relatively low commodity prices and no power price cap, Spanish solar and onshore wind-based PPA hydrogen production remained competitive against most other European countries reviewed by ICIS, with the exception of northwest European offshore wind-based hydrogen production.

TOWARDS A TRADED MARKET

Renewable, fixed-price PPAs represent an essential step in the development a liquid traded market for hydrogen. Not only do they enable hydrogen producers to verify their hydrogen as renewable within the terms of the EU directives, they also allow investors in electrolysis plants to guarantee the cost of production and to access project finance today. This is on the basis that in the early stage of development, hydrogen production and consumption are likely to be closely co-located due to the absence of infrastructure.

Looking longer term, ICIS expects the situation to evolve as a result of three influences. As hydrogen infrastructure builds out and storage capacity is developed, the opportunity to trade hydrogen between location and over time will emerge, and with it a natural over-the-counter (OTC) market for the product. Further, as power grids across Europe utilise a higher share of renewables in an effort to decarbonise, periods of excess generation will likely become prevalent, resulting in instances of oversupply and substantial pressure to the power market. These instances will provide electrolyser owners with the chance to secure spot volumes of power, increasing output and supply of low-cost, renewable hydrogen.

Such a development would go hand-in-hand with the emergence of storage and transportation capacity. This would support OTC trade as hydrogen producers could market lower-cost, wholesale power market hydrogen outside of any contractual obligations, where participants seek to secure or sell additional physical volumes of hydrogen.

Upon such periods of open trade, price reporting agencies will have the opportunity to commence assessments of hydrogen, providing reference points for other market participants to conduct further trade.

Lastly, even in a market where PPAs are required, one can expect increasingly complex arbitrage between the highly volatile power market and the hydrogen market with new pricing constructs evolving that mimic an OTC market, though using PPAs as the contractual model.