CEPS RESEARCH REPORT

IS RENEWABLE HYDROGEN A SILVER BULLET FOR DECARBONISATION?

A critical analysis of hydrogen pathways in the EU

Mihnea Cătuți, Edoardo Righetti,
Christian Egenhofer and Irina Kustova

RR2021-02 | DECEMBER 2021

EXECUTIVE SUMMARY

Executive summary

The European Union's objective to reach net-zero greenhouse gas (GHG) emissions by 2050 requires, most importantly, the direct electrification of the economy, which could cover more than 60 % of end-uses according to various scenarios. This makes sense from an efficiency perspective. Nonetheless, there are limits to the extent to which direct electrification can be implemented. Hydrogen is considered to be a potential solution, particularly for sectors where full electrification would be either technologically impossible or too costly, mostly in hard-to-decarbonise industrial processes (such as ammonia, basic chemicals and primary steel production) and some segments of the transport sector (particularly maritime and long-haul aviation). Hydrogen may also provide solutions for long-term energy storage. Hydrogen's contribution to the buildings sector is expected to be limited.

For hydrogen to enable the decarbonisation of these sectors, it needs to be produced with minimal GHG emissions. While this can be achieved in multiple ways, including through pyrolysis or from sustainable biomass, the European Commission's hydrogen strategy outlines a central role for renewable hydrogen – produced from water electrolysis using renewable electricity. Consequently, the proposals made in the Fit for 55 package aim at setting sectorial targets that will stimulate renewable hydrogen consumption.

Therefore, the main focus over the next decades will be on the large-scale deployment of electrolysers. Electrolysis technologies are at different levels of technological readiness, with alkaline water and polymer electrolyte membrane being the most commercially available. The upfront capital expenditure for electrolysers remains high and further cost reductions are needed for making renewable hydrogen competitive. Ensuring a sufficiently high load factor for electrolysers – between 3 000 and 6 000 hours – can also reduce the influence of the capital expenditure on hydrogen production costs. When electrolysers have a high utilisation rate, the price of electricity becomes the dominant cost factor. Under such circumstances, access to high amounts of renewable electricity is a key driver of the competitiveness of renewable hydrogen. This will mostly rest on the ability to deploy sufficient new renewable energy capacities and on the selection of criteria based on which hydrogen will be labelled as renewable.

Regarding the first aspect, new renewable energy installations are already facing obstacles to deployment – mainly related to public acceptability, grid development and strenuous planning and permitting processes. Under such conditions, there may be difficulties in meeting the renewable capacity requirements for decarbonising the electricity mix and for covering the increased demand from the further direct electrification of end-uses, which will require an expansion in renewable capacities of previously unseen pace and magnitude. It has been estimated that for the 40 GW of electrolysis capacity planned by the European Commission for 2030, 80-120 GW of additional solar and wind capacities would be needed, which is equivalent to three times the Europe-wide renewables capacity increase from 2019.

By 2030, it is expected that around 70 % of electricity output – renewables and nuclear combined – will have nearly zero marginal costs. This will transform the economics of the power

sector. In spite of the currently high energy prices, there have been concerns that the market price signal and with it, the ability to remunerate existing assets, is insufficient to drive new investments. Moreover, there are concerns that the addition of renewable hydrogen production could create further tensions with the already challenging decarbonisation of the electricity mix. To name but a few issues, hydrogen production and support policies could affect electricity prices, competition for renewable resources, grid congestion and renewable electricity targets.

To avoid such problems, the decarbonisation of the electricity mix and the deployment of renewable hydrogen production need to be developed together. One way of ensuring that renewable hydrogen does not cannibalise the renewable electricity needed for decarbonisation would be for Member States to take into account the new projected electricity demand for producing hydrogen when preparing national energy and climate plans.

The second important aspect related to access to renewable electricity for hydrogen production is the criteria that will be used for certifying the renewable credentials of electrolytic hydrogen. These will be set by the end of 2021 through the implementing acts for the revised Renewable Energy Directive. Debate centres around the application of the principle of additionality, which seeks to ensure that the electricity for hydrogen production is only sourced from new renewable capacities that would not have been developed otherwise. This requirement stems from fears that the renewable power used for hydrogen would be compensated by dispatching additional fossil fuel-fired capacities, leading to a subsequent increase in CO_2 emissions.

The way in which the additionality principle is implemented will have an impact on the availability of renewable electricity for hydrogen production. A physical connection would be the simplest way to ensure that hydrogen is produced from renewable electricity, but this may not provide a sufficiently high load factor for cost-effective hydrogen production and comes with logistical hurdles for hydrogen transport. Moreover, the lead times associated with renewable investments compared with electrolysers are also considered potential barriers. Directly linking electrolysers to specific renewable installations could go against a 'whole-system' approach, which is especially important from the perspective of sector integration. The contribution of electrolysers to providing grid flexibility would be diminished and hydrogen would not be produced from other climate-neutral electricity sources, such as nuclear energy or existing renewable energy sources. Renewable power generation and hydrogen production could also be matched on a 'system level', but this loose form of connection may fail to appropriately certify the renewable nature of hydrogen. Usage of guarantees of origin is not sufficient – geographical and temporal connections are also needed.

Thus, robust criteria for certifying the renewable nature of hydrogen should be established, while also allowing for the certification of low-carbon hydrogen produced from electricity that meets the requirement of 70 % GHG emissions savings and the carbon intensity set out in the taxonomy. In line with the strategies for hydrogen and energy system integration, the upcoming hydrogen and decarbonised gas package is expected to recognise the role of low-carbon hydrogen. Labelling just part of the electrolytic hydrogen production using grid electricity as renewable could improve the economics of electrolysis, particularly in countries with a lower carbon intensity of the electricity mix, where on-grid electrolysis could be achieved below the taxonomy threshold. Ultimately, ensuring that sufficient safeguards are in place for reaching climate neutrality by 2050 is most important. If such low-carbon hydrogen could be certified based on strict estimates of the CO_2 content of the grid electricity, it could still find potential customers even if it is not labelled as renewable. This could help avoid oversizing and underutilising the electrolyser, which could reduce the capital expenditure (CAPEX).

For meeting the expected hydrogen demand – though this should not be overestimated – the EU should make use of all available sources of low-carbon electrolytic hydrogen. Hence, this report looks at two other potential sources – imports and nuclear energy-based hydrogen.

While the hydrogen economy value chain is of strategic importance to the EU, it is likely that not all demand will be (or needs to be) fulfilled domestically. Similar to other energy carriers today, trade is possible and for some Member States facing supply deficits it will even be desirable from a diversification perspective. Imports can also offer further access to inexpensive renewable hydrogen, which can enable a lower cost pathway to decarbonisation. The desirability of renewable hydrogen imports rests on two determinants: the costs associated with production and transport and the climate credentials of imported hydrogen, which ought to be measurable and verifiable.

Based on current estimates, no major cost advantage is expected for imports, given the higher transport, conversion and reconversion costs. Yet, imported hydrogen could be required irrespective of price competitiveness to cover a supply deficit, should that occur. Imported hydrogen would need to be subjected to a proper certification system based on a life-cycle assessment, which should also cover transport-related emissions. Consistent international rules and a rigorous regulatory framework would have to guarantee that the same standards that apply to hydrogen that is considered clean when produced within the EU are required for imports.

Meanwhile, nuclear energy could also provide opportunities for producing low-carbon hydrogen from electricity. But it does come with additional challenges. One is related to certification. While bringing similar reductions in emissions, nuclear energy cannot be labelled as renewable. Therefore, it would not contribute to the achievement of renewable targets and may have even lower value recognition than renewable hydrogen. Nuclear energy is also associated with safety and non-climate environmental concerns and public acceptance. For those Member States where acceptability is not a concern, low-carbon hydrogen certification could allow usage of decarbonised electricity from the grid, including nuclear, which could enable greater access to low-carbon electricity for hydrogen production. Generally, nuclear reactors use relatively small land areas per MWh of electricity produced, thus leading to less land utilisation. Hydrogen could also be produced on the site of nuclear power plants, allowing for high load factors. Several new innovative concepts could provide additional advantages for electrolysis.