Climate neutrality by 2040: can hydrogen help?

"Hydrogen rocks, and I am committed to making it a success" - EU Commission First Vice President Frans Timmermans, October 2020

“Our lifeblood will be hydrogen" - EU Energy Commissioner Kadri Simson, November 2020.

Introduction

The EU has committed to reaching climate neutrality by 2050. Hydrogen is touted by politicians as the way to decarbonise difficult sectors such as transport, heating and industry.

Yet using hydrogen risks prolonging the use of gas infrastructure, and locking investments into fossil fuels for decades to come. The EU needs to be doing the exact opposite - phasing out fossil fuels, including gas, to reduce greenhouse gas emission in line with science, and achieve its climate targets.

There is an exception: hydrogen made from renewable energy sources is truly zero-carbon and aligned with the EU’s climate neutrality target.

But while renewable hydrogen has a part to play in decarbonising the EU economy, this part is limited, and hydrogen is certainly no silver bullet for decarbonisation. It must not replace direct electrification with renewable energy, which is almost always more efficient than using hydrogen.

In this short briefing, we look at the various ways hydrogen can be produced and the emissions they entail and avoid. We also look at the renewable energy resources available to produce hydrogen; how far renewable hydrogen can be used and in which sectors.

Hydrogen and the EU

The EU is actively looking into how to increase hydrogen use.

In July 2020, the European Commission released its Hydrogen Strategy, which WWF criticised for promoting fossil fuels.

On the same day, the Commission launched a 'Clean Hydrogen Alliance' to identify what the hydrogen sector needs to contribute to the EU's path to climate neutrality. WWF sits on the Alliance's roundtable on the use of hydrogen in industry, in order to support the deployment and targeted use of renewable hydrogen only.

Hydrogen is also set to be an important part of national recovery plans - and the EU's recovery plan - as well as the EU's upcoming Industrial Strategy, which is being reviewed and relaunched in the light of the Covid-19 pandemic.

Hydrogen will also be a key topic as trans-European energy network rules are reviewed by the Commission this year, and for the European Parliament as it finalises its non-legislative report on a hydrogen strategy for Europe, which will be voted in plenary later this year.

How is hydrogen made?

Hydrogen is only as clean as the energy used to produce it.

Currently, over 95% of hydrogen is produced using fossil fuels like gas and coal[1]. This is done by heating natural gas with steam to produce a 'synthesis' gas, which is then separated to obtain hydrogen, or by converting coal into a similar 'synthesis' gas and separating it. These methods emit high levels of carbon. Hydrogen production from natural gas and coal is today responsible for around 830 million tonnes of carbon dioxide emissions per year, which is the equivalent of the CO2 emissions of the United Kingdom and Indonesia combined.[2] Even if some of those emissions can potentially be captured, this option 'locks us in' to fossil fuel infrastructure, when we need to end our use of coal, oil and gas rapidly. Another, less common way to make hydrogen also uses fossil fuels, but heats them instead ('pyrolysis').

The third way to produce hydrogen is via electrolysis, or using an electric current to separate water and obtain its hydrogen. If the electric current comes from wind and solar power, the hydrogen produced can be considered 'green'. However, if it comes from non-renewable sources, it will also entail carbon emissions or, in the case of nuclear, come from an unsustainable source.[3] Moreover electrolysis, however it is powered, requires significant amounts of water.

Finally, electrolysis is highly energy intensive - it takes five times as much energy to produce the hydrogen than the end result represents. Using electrolysis extensively to produce hydrogen would increase overall energy demand as well as overall electricity demand, which could undermine the EU's energy efficiency and renewable energy targets.

Therefore, in WWF's view, hydrogen should be produced only by electrolysis using renewable energy sources, and only in a limited amount. It should not be used at all when direct electrification with renewable energy is possible, because it increases total energy consumption, electricity demand and total renewable electricity demand.

[1] IRENA, Hydrogen from renewable power. Technology outlook for the energy transition, (2018), p. 13.

[2] Idem

[3] For instance, the process of electrolysis can rely on using nuclear as primary energy.

Supply and demand for renewable hydrogen

In order to power renewable hydrogen at scale we need a large amount of electricity sourced from renewables.

Ideally, renewable hydrogen would be produced from surplus wind and solar power, which would otherwise be curtailed due to grid congestion, and be produced domestically or within the EU.

However, we do not currently have enough electricity produced from renewable sources to cover all the renewable hydrogen needs. Therefore renewable hydrogen could also come from some limited additional renewable electricity generation. This means we should be investing in additional renewable energy capacity now.

Potential uptake of renewable hydrogen from 2030

Today, renewable hydrogen is not financially competitive compared to fossil-based hydrogen due to the differences between gas and electricity prices. However, renewable hydrogen could become more competitive than fossil-based hydrogen by 2035 in Europe. For this to happen, the EU must develop a market for renewable hydrogen production through electrolysis by investing in innovation on a larger scale. The CO2 price will also be a factor in the cost.

Producing renewable hydrogen entails high conversion losses - meaning lots of energy is lost during the process, for example as heat. For this reason, it should not compete with the production of renewable electricity that could be directly and more efficiently used to decarbonise key sectors such as home heating and transport. Energy efficiency and carbon-free electrification should be made a priority to achieve decarbonisation across all sectors by 2040. This would already require a massive upscaling and deployment of renewable energy sources (predominantly photovoltaics as well as onshore and offshore wind energy) as well as the necessary grid infrastructure development.

In other sectors like some energy intensive industries, shipping and aviation, electrification is not possible, and here hydrogen can play a role. Not for unsustainable practises such as oil refining and fertiliser production, which need to be phased out altogether, but in essential industries like steel and basic chemicals, where renewable hydrogen is needed for full decarbonisation.

When should renewable hydrogen not be used?

Whenever electrification is possible, the hydrogen option should be ruled out. Electrification is far more efficient. For example, heating systems and the transport sector can be decarbonised through electrification and energy efficiency.

The EU's priority should be moving domestic and commercial heating away from gas, and towards renewable energy and heat pumps, through district heating. Hydrogen is not an appropriate technology in the decarbonisation of passenger vehicles such as cars and vans because of the huge energy losses incurred at the point of combustion. Exemptions in the transport sector shipping and aviation, where there are significant technological barriers to electrification.

Renewable hydrogen and energy-intensive industries

Hydrogen is currently used mostly for unsustainable practices such as oil refining and wide-scale fertiliser production, and most of this hydrogen is produced using fossil fuels. These industrial applications should decrease in the future decades as electric vehicles gain market share and fertiliser use falls.[4]

[4] See also the graph 'Global demand for pure hydrogen' (1975-2018), IEA The Future of Hydrogen: https://www.iea.org/reports/the-future-of-hydrogen

However, demand will grow in other areas, such as the steel and chemicals sectors. Since such energy-intensive sectors are here to stay, they should be candidates for the use of renewable hydrogen, to help them fully decarbonise.

Environmental limits

While renewable hydrogen is far better in climate terms than other types, it still has an impact on the environment, in terms of land use, water use, and biodiversity. As mentioned above, hydrogen produced through electrolysis requires large amounts of water - for the production of 1 kg of hydrogen, about 9 litres of water are needed.[5] Despite this, the European Commission's new hydrogen strategy, which shows the path to development of renewable hydrogen powered through electrolysis, makes no mention of environmental impact.

The roll-out of hydrogen envisaged by the Commission would have a significant impact on water resources. Sustainability criteria must be put in place. For instance, WWF's water-risk filter could be used to choose a site for electrolysers, in order to not increase water stress and protect biodiversity hotspots.

Conclusion

Now is the time for the EU to invest in clean production technologies to be deployed over the next decade, and avoid a fossil-fuel lock-in.

The EU can do this by:

- Giving priority to energy efficiency and direct electrification over renewable hydrogen where feasible, for example transport and home heating;
- Funding renewable hydrogen projects and infrastructure over fossil fuels and nuclear;
- Defining 'clean hydrogen' according to the 'do no harm' principle, and the EU sustainable investment Taxonomy. This means that 'clean hydrogen' should 'make a substantial contribution' to climate action by having a carbon intensity no higher than 2.256 tCO2e/tH2.[6]
- Clarifying how future hydrogen infrastructure will be managed, via a regulatory framework on planning, regulation and managing conflicts of interest.
- Giving priority to domestic EU production of both onshore and offshore renewable hydrogen (from excess and additional renewable electricity) and accompanying this with appropriate reskilling and investment strategies.
- Developing an EU lead market for renewable hydrogen technologies before 2030 for sectors that really need it, by mapping out demand for hydrogen;
- Defining which sectors cannot achieve decarbonisation without renewable hydrogen, such as steel, basic chemicals, energy storage, aviation and shipping.
- Defining clear sustainability criteria and import-export processes which account for the carbon footprint of traded hydrogen as well as impacts on water and land use as well as other environmental and social impacts.

Renewable hydrogen has a future. That future is confined to certain energy intensive industries, the shipping and aviation sectors, where electrification is not possible, in order to reduce their emissions and contribute to the EU's climate goals. Despite EU Energy Commissioner Simson's words, hydrogen will not be the 'lifeblood' of the EU. However, provided the system overall is based on energy efficiency and renewable electricity, hydrogen can be an important and strategic artery.

[5] Is hydrogen the fuel of the future? ScienceDirect (2019)

[6] The "do no harm test" would exclude investments in hydrogen powered by nuclear power. See also the NGO analysis of the draft Taxonomy rules. It should be noted that the estimates from a study from the RSC Energy & Environmental Science Journal (2018) show a carbon footprint for solar-based electrolysis ranging from 1.32 to 2.5 kgCO2/KgH2, with the central value being **2.2 kgCO2/KgH2.** Moreover, it seems like most recent calculations by solar industry players show an environmental footprint ranging between **1.32 and 2 tCO2/tH2.**

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