The role of hydrogen in supporting carbon neutrality by 2040

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Introduction

Hydrogen (H2) is perceived as the magical fuel to decarbonise key sectors such as transport, heating and industry, and for reaching net zero emissions by 2050, due to its storability and low carbon potential. In this context, this briefing outlines the production routes of hydrogen and its decarbonisation impacts. It also looks at the available resources for renewable hydrogen, its potential uses in decarbonising industrial applications and its contribution to meeting the EU's climate goals, while also highlighting its limits. Lastly, it draws upon the current political discourse around hydrogen at the EU level, especially in light of the release of the European Commission's Hydrogen Strategy and the launch of the Clean Hydrogen Alliance.[1] The hype and hopes for H2 are rising as it is receiving significant public support within the EU recovery plans and the upcoming new EU Industrial Strategy. [2] As the EU sets the course for its recovery after the COVID-19 pandemic and the resulting economic damage, now is a crucial time to dispel the myths around H2 and outline where it can be used to further EU goals of climate neutrality.

Production routes of H2

Why is everyone talking about hydrogen (H2)?

The attractiveness of hydrogen resides in the idea that it is considered a 'clean', zero-emissions energy carrier: at the point of combustion, the only waste produced is pure water.[3] However, hydrogen is only as clean as the energy used to produce it. Other appealing characteristics of H2 are that it is light, can be transported in a liquid, gaseous or solid form

[1] The EC Hydrogen Strategy was published on 8 July 2020, the Clean Hydrogen Alliance was launched on the same day: https://ec.europa.eu/commission/presscorner/detail/en/FS_20_1296

[2] The EC will release its new EU Industrial Strategy on 18 March 2021. Large amounts of recovery money is foreseen to develop the so-called 'EU Hydrogen economy' through the EU recovery plans. FR, DE, ES and PT have already announced a substantial amount of recovery money to be dedicated to fund hydrogen projects, such as the new investment plan for hydrogen aircraft in FR and the commitment to develop the production of 'climate-neutral' steel in Germany.

[3] See: Hydrogen Council, How hydrogen empowers the energy transition

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(through tanks and pipelines), and may be stored for long periods of time. However, both transportation and storage of hydrogen come with safety concerns as leakage can occur and hydrogen is highly explosive.

Hydrogen as a product is not necessarily a low carbon technology: it is important to acknowledge that its green credentials depend on its mode of production. This is generally distinguished using the colours: “black”, “grey”, “brown”, “blue”, “turquoise”, “pink”, “yellow” or “green”.[4] However, these colours do not clearly explain the production routes of hydrogen. Thus, reference should be made to the energy source as well as to the production process applied to produce hydrogen.

Hydrogen powered by fossil-fuels: “Grey”, “black”, “brown” hydrogen
These colours refer to hydrogen from fossil fuels (respectively from natural gas, coal, and lignite), which generate significant GHG emissions along the production route.

Main production routes:

- Steam Methane Reforming (SMR): involves reacting natural gas with steam at high temperatures over a catalyst to produce synthesis gas (a mix of hydrogen and carbon monoxide), which is then processed to separate the hydrogen.
- Coal Gasification: coal is converted into a synthesis gas that is then transformed into hydrogen and CO2.

Hydrogen powered by natural gas hydrogen or coal gasification: “Blue” hydrogen
Blue hydrogen refers to the production of hydrogen powered by natural gas or coal gasification, through steam reforming, with Carbon Capture and Storage (CCS). It generates carbon emissions from the SMR process but these emissions are captured and can then be stored, meaning that potentially no/low CO2 emissions reach the atmosphere as part of this process. With blue hydrogen, a higher share of total emissions could be captured and lower total energy consumption.[5]
Some argue that generating hydrogen through bioenergy with carbon capture and storage (BECCS) has the potential to provide net negative emissions overall, though this process has yet to be demonstrated at scale.[6]

Main production routes:

- Steam Methane Reforming (SMR) + Carbon Capture and Storage (CCS)
- Coal gasification + CCS
- Autothermal Reforming (ATR): ATR involved
- Bio-energy with carbon capture and storage (BECCS) + gasification

Coal gasification generates higher emissions than SMR or ATR. Additionally, about 50% of SMR emissions and 90% of ATR emissions can be captured.

[4] See: IEA report (2019), p.33
[5] Idem
[6] Examining the evidence on Bioenergy with Carbon Capture and Storage (BECCS), A G Climate & Energy Ltd, WWF UK, 21 July 2020

Pyrolysis hydrogen: “Turquoise”, “pink”, and “yellow” hydrogen
Both turquoise and pink hydrogen refer to the production of hydrogen via pyrolysis, but they differ in the primary energy used to produce hydrogen. Pyrolysis is a process of chemically decomposing hydrocarbon materials at elevated temperatures in the absence of oxygen. Since no oxygen is present, the hydrocarbon material does not combust.

Main production routes:

“Turquoise” hydrogen

- Through pyrolysis (can be powered by renewable electricity or natural gas), considered as ‘low-carbon’ hydrogen[7]

“Pink” or “yellow” hydrogen (or nuclear hydrogen)

- Through pyrolysis or electrolysis (powered by nuclear)

Renewable hydrogen: “Green” hydrogen
Green hydrogen refers to relying on renewable energy sources (solar, wind) to provide an electric current for electrolysis.

Main production routes:

- Through electrolysis of water using electricity powered by renewable sources (solar, wind)

Electrolysis

A process by which ionic substances break down into simpler substances when an electric current passes through them.

Electrolysis does not mean green hydrogen

- The carbon footprint of hydrogen through electrolysis depends on the primary source of energy and/or the carbon intensity of the electricity input. The application of electrolysis using non-renewable forms of power generation (i.e. nuclear), including biopower, does not produce ‘green’ hydrogen.[8]
- Moreover, electrolysis requires significant volumes of pure water. The impacts of electrolysis on water, biodiversity, land-use and raw material use need to be assessed and carefully handled to avoid additional stress on freshwater ecosystems and drinking water resources.
- Finally, electrolysis is also energy intensive, and increases overall energy demand as well as overall electricity demand (this may be in conflict with both energy efficiency and share of renewable electricity targets.)

[7] It’s considered ‘low-carbon’ hydrogen by various stakeholders such as the European Commission. However the use of natural gas should not be underestimated and only renewable (green) hydrogen should be considered as ‘clean’ hydrogen.
[8] For instance, the process of electrolysis can rely on using nuclear as primary energy

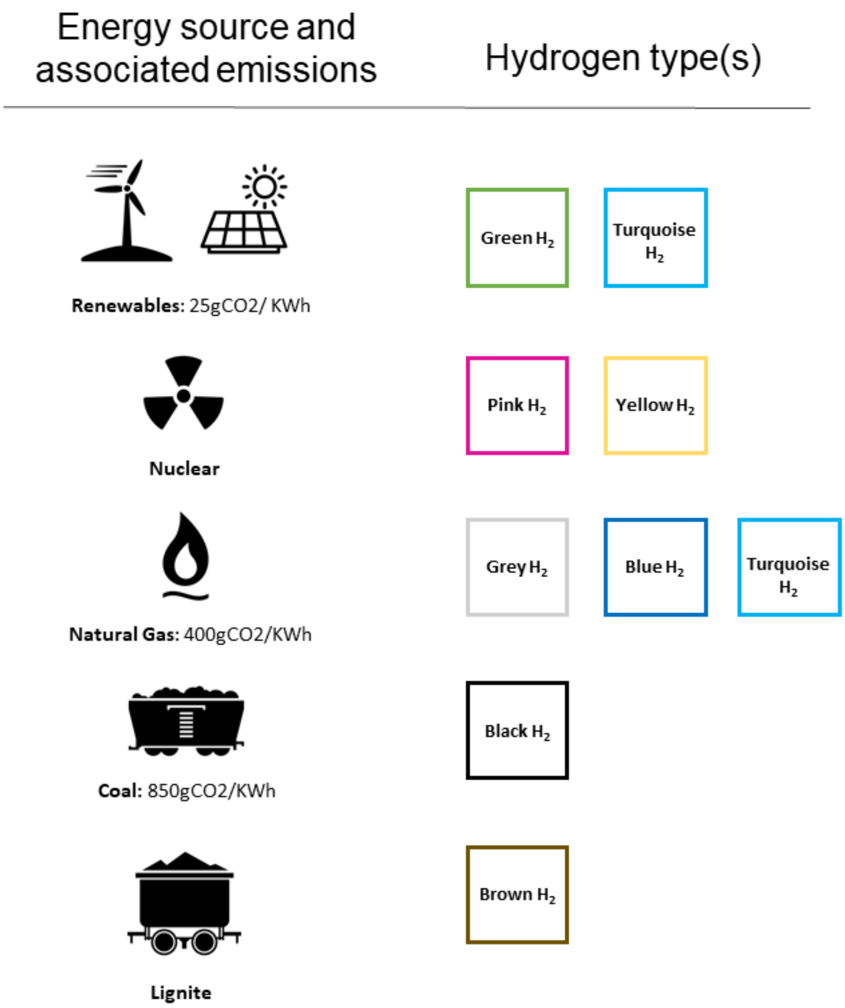


Figure of different types of H2 and their associated energy sources: The energy sources above are ranked from least to most carbon produced, with renewables being the least harmful for the environment. Although nuclear is high up on this list, one must be aware of its significant environmental impacts. As such, only renewable H2 can help achieve climate neutrality.

Different production routes of hydrogen, their CO2 impact and decarbonisation potentials

The majority of hydrogen in use today is not “green”. Natural gas is the primary source of hydrogen production, closely followed by coal.[9] Over 95% of current hydrogen production is fossil fuel based.[10] Such reliance on fossil fuels implies that hydrogen production currently leads to significant carbon emissions: 10 tons of carbon dioxide are released for each ton of hydrogen (tC02/tH2) produced from natural gas.[11] Consequently, hydrogen production from natural gas and coal is today responsible for around 830 million tons of carbon dioxide emissions per year, which is the equivalent of the CO2 emissions of the United Kingdom and Indonesia combined.[12]

Hydrogen is not climate neutral per se; it depends on how you make it and for what purpose

Hydrogen is an energy carrier

Hydrogen is not a primary source of energy but an energy carrier requiring conversion from an energy source, which implies high energy losses. Thus, a reflection on the uses of hydrogen is needed. Hydrogen is also a by-product of certain industrial processes, where it is referred to as ‘fatal hydrogen’.[13] In coking plants and refineries, and during processes such as the electrolysis of brine to obtain chlorine, hydrogen is involuntarily produced. Today, it is either reused, if a consumer exists on the same industrial site, used to produce heat or is simply released into the atmosphere naturally or via burning (creating water which is released in the atmosphere). Whether hydrogen is produced from renewable electricity, fossil fuels or nuclear significantly affects the objective of reaching climate neutrality by 2040.

Electrification first

The required share of renewable energy sources (RES) in the power mix should be around 80% in order to gain environmental advantage in the use of hydrogen over direct electrification.[14] Furthermore, hydrogen has substantial disadvantages compared to direct electrification, as it increases the total energy consumption, total electricity demand and total RES electricity demand.

[9] See : IEA report (2019), p.38
[10] IRENA, Hydrogen from renewable power. Technology outlook for the energy transition, (2018), p. 13
[11] See : IEA report (2019), p.38
[12] Idem
[13] See: https://www.certifhy.eu/images/D1_2_Overview_of_the_market_segmentation_Final_22_June_low-res.pdf
[14] See: https://www.oeko.de/presse/archiv-pressemeldungen/presse-detailseite/2019/bedeutung-von-power-to-x-fuer-den-klimaschutz-in-deutschland

Economic and geographical challenges for renewable hydrogen

Supply and demand for renewable hydrogen

Governments are deploying their hydrogen plans and looking at its potential uses to decarbonise every sector of the economy: from home heating to transport as well as the industrial sector, in order to achieve carbon neutrality by 2050 at the latest.[15] Will there be enough renewable hydrogen available to cover the rising demand? The gap between the rising demand for renewable hydrogen and its current or potential levels of production needs to be recognised.

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 excess/surplus renewable electricity (powered by solar and wind), which would otherwise be curtailed due to grid congestion, and be produced domestically or within the EU. However, we do not have enough electricity produced from renewable sources to cover all the renewable hydrogen needs. Total EU renewable energy sources could replace about 15% of total current gas use (all gases used). Switching all the current hydrogen production to renewable hydrogen processes would require an electricity demand of 3600 TWh/a, which is substantially more than annual EU electricity generation.[16] The total amount of EU renewable electricity generated in 2017 was 974 TWh/a. Based on this figure; the excess renewable power would not be enough to cover the power demands of hydrogen production. This is also confirmed by the Paris Agreement Compatible (PAC) scenario, which shows figures on how much Renewable Energy Sources (RES) need to be scaled-up in terms of TWh and the amount of H2 needed for Industry.[17] Therefore, renewable hydrogen should be produced from excess/surplus renewable electricity and additional renewable electricity generation. It is important to note that renewable hydrogen imports from third countries must only be considered as a last resort and respect clear environmental and social criteria.

Geographic dimension

In order to meet the forecasted hydrogen demand, some EU Member States such as Germany are considering importing green hydrogen from non-EU countries (i.e. North Africa

[15] United- Kingdom, France, Germany and Portugal have deployed hydrogen plans to decarbonise their economies and achieve net zero by 2050, and implement hydrogen paths in every sector: from heating, to transport to and to industry.

[16] See: hydrogen from wind energy and solar power, the future

[17] Electricity demand within the total industry final energy demand in EU28 (TWh) will scale up from 900 TWh/a in 2015 to 1500 forecasted for 2050. The demand for renewable hydrogen in Industry would also double from 2030 to 2050. See: Slide 9, PAC Scenario Presentation (CAN-E, EEB)

to Europe) where there is a greater potential for renewable energy at a large scale which can power a substantial amount of electricity. Hydrogen would be captured, stored and exported.[18] However, renewable hydrogen imports, which should be prioritised over fossil-based hydrogen, must be guaranteed to be made from 100% renewable energy. In addition, it should not slow down the energy transition towards energy efficiency and renewables in the exporting country.[19] In case fossil-based hydrogen (pyrolysis, natural gas) imports are considered, it must be done under strict environmental and social conditions.

Some non-EU countries are also seeing the potential of exporting their hydrogen production to respond to the growing global demand (e.g. Australia).[20] Domestic production of hydrogen should be given priority (i.e. through the upscaling of the commercialisation of electrolysers and the development of an internal EU market for renewable hydrogen) as it is considered safer, cheaper (saving transport costs) and cleaner; and should be subject to stronger track and trace.[21] Moreover, it would also guarantee less energy losses. Finally, it will contribute to maximising the potential net jobs gains from the energy transition, if accompanied by appropriate reskilling and education programmes.

If renewable hydrogen is used close to where it is produced, supply costs are almost zero. However, should imports be considered, the following aspects must be taken into account:

- Standards for the imported hydrogen to the EU have to be implemented;[22]
- Carbon intensity of the grids in non-EU countries need to be taken into account prior to considering imports;
- Sustainability criteria should be defined. Renewable hydrogen powered by electricity and produced through electrolysis has an impact on land use and biodiversity, as electrolysis requires vast amounts of water. Thus, the sustainability criteria should consider the impact on resources used such as water and land.
- Trustable Certificates are crucial. Renewable hydrogen production should come from renewable electricity production that meets electricity demand. It should come from the surplus of renewable electricity production only. The local renewable electricity production should not slow down due to renewable hydrogen exports.

[18] The German Hydrogen Strategy has been scheduled to go out at the end of 2019, but has been delayed since. Germany is thinking of developing a specific partnership with Africa to import hydrogen

[19] Remark: the issue of Morocco having 50% coal power in their mix and new RES electricity going into hydrogen production for Europe should be mentioned as a potential slowdown of the local energy transition. Which country will be credited with emissions reductions is also an international emissions accounting question possibly relevant for NDCs.

[20] See: Opportunities for Australia from Hydrogen exports

[21] Note: Pipelines are likely viable only up to a maximum of 1500 – 2000 km. Imports from further away mean imports by shipping of methanol or ammonia. This would mean that the steel sector cannot be supplied in this way because it needs hydrogen as hydrogen (like steel for instance who need it as a feedstock - so the closer to the plant the better).

[22] ECOS paper: https://ecostandard.org/wp-content/uploads/2020/03/ECOS-BRIEFING-GUARANTEES-OF-ORIGIN.pd

Gas grids & hydrogen production

Several stakeholders, H2 producers, and the gas lobby are calling for the deployment of hydrogen at large scale to decarbonize power, buildings, transport and industrial sectors.[23] The interest in blending hydrogen within current gas infrastructures is high. However, the potential of blending hydrogen into the current gas grid seems to be limited and would require harmonization across EU Member States (as blending depends on the type of gas grid, which differs for each country).[24] Supporting H2 should not mean supporting blending in order to enable the evolution of the fossil gas industry.[25] It should be limited, and strictly regulated.[26] Existing gas infrastructure is sufficient and does not need more subsidies.[27]

The European Commission is planning to repurpose existing gas pipelines in order to transport hydrogen across EU borders. Transporting pure hydrogen through pipelines would necessitate the repurposing of the current grids or development of new grids or pipes, which would mean investment in the development of new fossil fuel infrastructures.[28] To achieve climate neutrality by 2040, it is clear that the phase-out of fossil fuels (including gas) should start today.

Moreover, as set out above, it is far from certain that sufficient renewable hydrogen can be sustainably produced using renewable electricity to meet even existing gas demand and use. H2 cannot not be used as a Trojan horse to promote continued fossil gas infrastructure deployment and a business-as-usual scenario. This could lead to:

- Limited decarbonisation of the existing gas grid through blending hydrogen rather than investing in new, carbon-neutral electricity infrastructures;
- A push for hydrogen to be used through Carbon Capture and Storage (CCS) in Energy Intensive Industries (such as cement and steel for instance), when CCS is not proven as a carbon-neutral technology. Thus, CCS deployment must be limited to process emissions for which there are no alternative mitigation options, considering its environmental and technological risks, as well as its high capital and operational cost. It should adhere to strict environmental and social safeguards.[29]

[23] The gas lobby is advertising gas as "transition fuel" from coal and the potential of hydrogen to the EU gas grid. See: https://www.fch.europa.eu/sites/default/files/Hydrogen%20Roadmap%20Europe_Report.pdf
[24] Idem, p.22
[25] Bellona, Hydrogen from Electricity – Setting Sustainability Standards to Meet Innovation, Deployment and Climate Action, p.10.
[26] Note: The risk of supporting blending is to continue to support public investments into fossil fuels. When we support a quick phase-out of fossil fuels, starting with coal mostly disappearing from the mix by 2030, fossil gas by 2035.
[27] See NGO policy brief (October 2020): EU gas infrastructure does not need more subsidies
[28] According to the EC Hydrogen Strategy, published on 8 July 2020
[29] See: WWF & CMW recommendations on a new EU Industrial Strategy

Therefore, a strategy regarding the transportation of hydrogen (besides pipelines) should be defined. Additionally, infrastructure planning for hydrogen needs to be strategic (planning guidelines); in order to avoid stranded assets and be based on independent planning of actual priority needs and a reasonable estimation of available supply. Production of renewable hydrogen on site (clusters approach) should be favoured (as it's best for pure hydrogen production for steel, for instance). Building electrolysers close to power grid nodes or industrial sites that will use renewable hydrogen would reduce the need for transportation infrastructure.

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. The current cost of electricity produced by renewable energy sources, electrolyser prices and the lack of technological feedback are the main barriers to the deployment of the production of renewable hydrogen through electrolysis. However, renewable hydrogen is expected to become more competitive than fossil-based hydrogen by 2035 in China.[30] The same could be achieved in Europe if the EU develops a market for renewable hydrogen production through electrolysis by investing in innovation at a larger scale. The deployment of cheaper electrolysers by 2035 would also depend on whether CO2 price increases.[31]

This scenario is envisaged in the framework of the recently launched Clean Hydrogen Alliance, which should identify the needs for the hydrogen sector to contribute to the EU's climate-neutrality goal.[32]

Due to large conversion losses, recourse to the use of hydrogen is less efficient than using electricity directly - which questions the entire viability of hydrogen as a clean energy solution.[33] The production of renewable hydrogen 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 in achieving 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 – which is a capacity issue in the near term.[34]

[30] Bloomberg projection
[31] See : EU-wide innovation support is key to electrolysis in Europe
[32] See the EC Industrial Strategy released on 10 March 2020, which announced the creation of the Alliance on Hydrogen. The Clean Hydrogen Alliance was launched on 8 July 2020
[33] DUH Position paper, page 7
[34] See: WWF recommendations for a fair & just recovery after Covid-19

What is most cost effective for decarbonisation to happen by 2040?

Heating and Transport

Wherever there is a possibility to electrify first, the option to use hydrogen should be ruled out automatically. Electrification and energy efficiency can help decarbonise heating systems today.[35] The EU's priority should be moving domestic and commercial heating away from gas, and towards renewable energy and heat pumps (through district heating).[36]

Applying hydrogen technology in this sector is an inefficient solution where electricity can be used to directly fuel propulsion and energy efficiency losses, as a hydrogen powered fuel-cell vehicle requires three times more energy per kilometer than a battery-powered vehicle.[37] The development of electric batteries and the deployment of electric charging stations for vehicles should therefore be made a priority to decarbonise the automotive industry. It makes no sense to develop hydrogen fuel-cell passenger cars due to the energy efficiency losses. Thus, the use of renewable hydrogen should be considered only in its potential to fuel heavy transport (trucks), shipping and aviation, where there are significant technological barriers to electrification in the near to medium term.[38] Hydrogen is not an appropriate technology in the decarbonisation of passenger vehicles – including cars and vans. Electrification and deployment of electromobility provides a clear and feasible pathway to fully decarbonise this part of the transport sector. Energy efficiency and the switch to other means of transport such as cycling are also part of the solution to decarbonise this sector.

Energy Intensive Industries

It's important to note that current uses of hydrogen are mostly for unsustainable practices such as oil refining and wide-scale fertiliser use, and are supplied through fossil fuels. These industrial applications should not be the only ones relying on renewable hydrogen, as their production should decrease in the future decades (i.e. oil refineries (fuel for cars), ammonia (fertilizer production)).[39]

However, future demands are foreseen for new applications in the steel and chemicals sectors. Renewable hydrogen infrastructure and applications would be needed for the full

[35] See Businesses & NGOs open-letter to Commissioner Timmermans: Decarbonising the EU building stock with available solutions and no direct use of hydrogen

[36] We still acknowledge that there could be a very limited role for hydrogen for seasonal balancing (i.e. in EU countries which experience colder winter and could have shortage of electricity supply)

[37] DUH position paper, page 7

[38] Along with other potential renewable solutions like synthetic fuels

[39] 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

decarbonisation (abatement of process emissions) of certain hard-to-abate sectors like basic chemicals, iron and steel.

- Steel, basic chemicals and iron as examples

Hydrogen can serve as a feedstock for low carbon steel manufacturing. Hydrogen can be used in two ways in steel production: by injecting hydrogen into a blast furnace (H2-BF) or by using hydrogen to reduce iron oxides or DRI (H2-DRI).[40] The second route (use of hydrogen to replace coal, coke and gas for ironmaking) would have the most CO2 emissions reduction potential: 90% compared to the CO2 emissions of the current blast furnace route.[41] See for example, the Hybrit project with a real potential to abate the process emissions and be the first 'steel fossil-free products' on the market by 2026.[42]

As an example of the potential impact, the global iron and steel industry accounts for approximately 4% of total global CO2 emissions.

Environmental limits for a widespread development of H2 applications

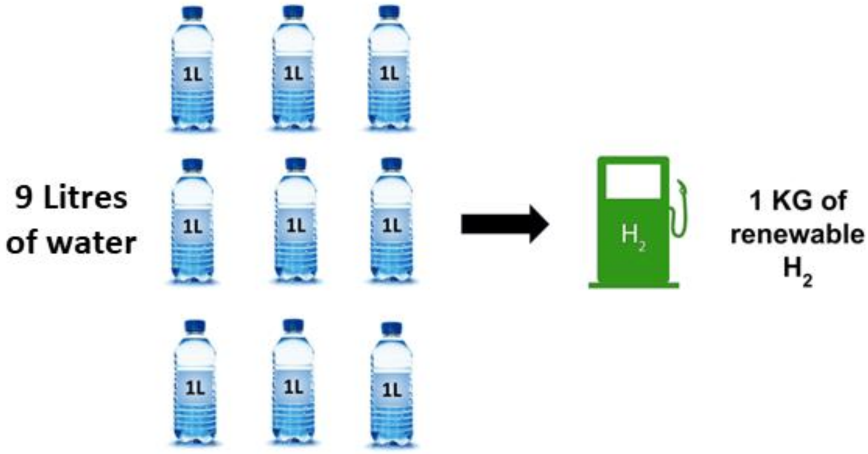
Besides the cost-effectiveness argument, the widespread development of renewable hydrogen applications also has an impact on the environment: land use, water use, and biodiversity. Hydrogen produced through electrolysis requires a substantial amount of water. Until now, the water intensity of hydrogen production has not been properly considered. The new EC hydrogen strategy, which shows the path to development of renewable hydrogen powered through electrolysis, makes no mention of the hydrogen economy's impact on water resources.

Hydrogen powered through electrolysis is water intensive. For the production of 1kg of hydrogen, about 9 L of water are needed.[43] Hydrogen production by electrolysis uses water in a direct (as a feedstock) and indirect way (as a cooling fluid for thermoelectric generation of electricity that is needed to convey, distill and electrolyze some parts of the water used as feedstock).[44] Feedstock needs to be pure water, and cooling water can be fresh or saline water which requires no desalting or purification.[45] Thus, the water used in the electrolysis process is usually pre-treated to a high level of purity, and is generally deionized.[46]

[40] See article from Bellona: Hydrogen in steel production: what is happening in Europe – part one (2021)
[41] See the conclusions of the article: Hydrogen Ironmaking: How It Works
[42] See: http://www.hybritdevelopment.com/; and https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF-Germany-CCU-Position-Paper-engl.pdf
[43] Is hydrogen the fuel of the future? ScienceDirect (2019)
[44] The water intensity of the transitional hydrogen economy, Michael E Webber (2007), page 2
[45] Idem, page 3
[46] See: Life Cycle Assessment and Water Footprint of Hydrogen Production Methods: From Conventional to Emerging Technologies (2018), page 7

The development of the hydrogen economy as envisaged by the EC represents a significant potential impact on water resources. Sustainability criteria must be put in place. For instance, the WWF water-risk filter could be used for choosing a site to host electrolysers, in order to not increase the water-stress and already existing biodiversity hotspots. There could be promising new ways of using wastewater and sunlight to produce hydrogen; however these ways are only explored at project scale currently.[47]

Finally, given the limited sea space and electricity-intensity of hydrogen, priority should be given to direct electrification with renewables and shifting away from gas. Both onshore and offshore renewable hydrogen should only be produced from excess and additional renewables capacity.



Governance & policy timeline

Interests and discussions on the future of hydrogen are growing in Brussels.

The European Commission announced the development of a Clean Hydrogen Alliance (CHA) on 8 July 2020, based on the success of the European Battery Alliance.[48] The main goal of the CHA is to identify the needs of the hydrogen sector to contribute to the EU's climate-neutrality, through the work of different roundtables. WWF EPO will be taking part in the work of the CHA roundtable on the use of Clean Hydrogen in Industrial applications. WWF EPO as well as other NGOs have always requested that the European Commission should create

[47] Greenlysis project (2010-2012)
[48] Announced by Commissioner Thierry Breton during the press conference on the launch of the new EC Industrial Strategy, 10 March 2020. The Clean Hydrogen Alliance was launched on 8 July 2020.

such a platform in a transparent manner that is open to civil society representatives and have at its heart the production of renewable based hydrogen.

Furthermore, the European Commission released its Hydrogen Strategy on 8 July 2020, which includes a clearer definition whereby 'clean hydrogen' means only renewable H2; and low carbon hydrogen is defined as fossil-based hydrogen with CCS.[49]

Moreover, there are several upcoming EU legislative initiatives where hydrogen will be debated and where H2 is likely to play a big role, such as the TEN-E Regulation currently under review, with the EC proposal released in December 2020. The European Parliament is also finalising its INI report on a Hydrogen Strategy for Europe, to be voted on in plenary later this year.

Conclusion

Given the current post-COVID 19 context, it is of great importance to not return to pre-COVID damaging and polluting economies. We need to think of the recovery as aiding the transformation to a cleaner, healthier and stronger economy and society, making net zero carbon and circular products through cleaner production processes. This should go hand in hand with providing sustainable jobs as pushed in both the Industrial Strategy and the Circular Economy Action Plan. Industrial assets often last 30-40 years or longer and between 30% and 53% of cement, steel and steam cracker plants, will require major reinvestments for renewal in the next few years (5-10 years).[50] It is crucial that the EU puts in place the right policy frameworks and that incentive structures, as well as investments made, are compatible with the long term vision of a climate neutral Europe. Remaining emissions in a climate neutral Europe will come only from agriculture (mainly livestock) and from industrial process emissions. Now is the time to lay the groundwork for clean production technologies to be deployed over the next decade.

Therefore, it is essential to build-up a no regrets scenario of zero carbon hydrogen production, avoiding any fossil-fuel investments, which would lock Europe into stranded assets and waste public and private money. The no regrets strategy for the deployment of green, zero carbon hydrogen needs to be based on the following principles:

- Give priority to energy efficiency and direct electrification over renewable hydrogen to decarbonize all sectors by 2040, where technically feasible (i.e. transport and home heating appliances);
- Support funding for renewable hydrogen projects and infrastructures over fossil fuels and nuclear;

[49]See annexes for more information regarding the take-overs in the EC Hydrogen Strategy
[50] See Agora study: A clean Industry package for the EU, page 3

- Define and classify 'clean hydrogen' according to the "do no harm test", and in line with standards set in the Taxonomy Regulation Delegated Act: i.e it should meet the criterion of making a substantial contribution to climate change by having a carbon intensity no higher than **2.256 tCO2e/tH2.**[51]
- Clarify governance of future H2 infrastructures. Define an overarching regulatory framework on planning, regulation and management of conflicts of interest.
- Give priority to domestic EU production of both onshore and offshore renewable hydrogen (from excess and additional renewable electricity) and accompany this with appropriate reskilling and investment strategies;
- Define priority sectors for the use of renewable hydrogen to make targeted use of limited sources of green hydrogen in sectors which could not achieve decarbonisation otherwise, such as some Energy Intensive Industries (i.e steel and basic chemicals), energy storage, aviation, and shipping;
- Develop a lead market in the EU for deployment of climate-neutral and renewable hydrogen technologies before 2030. The lead market must focus on priority sectors – Energy Intensive Industries (i.e. steel and basic chemicals), energy storage, aviation, shipping and heavy good vehicles through measures such as carbon contracts for difference, public procurement rules.
- Define clear sustainability criteria and processes of imports-exports which account for the carbon footprint of traded hydrogen as well as impacts on water and land use in addition to other environmental and social impacts. Introduce a criteria of "interference with local energy transition" which should address the impact of renewable electricity being used for the European hydrogen demand and thus not being available for decarbonisation of the local grid.

[51] The "do no harm test" would exclude investments into hydrogen powered by nuclear power. See also the NGO analysis on the DA Taxonomy. Technical analysis: the draft DA improves the TEG recommendation on the threshold. The current threshold is 80% of the fossil fuel comparator of 94gCO2e/MJ threshold (RED2), i.e. 18,8 gCO2/MJ = 2.256 tCO2eq/tH2 = **0,67gCO2/kWh.**

Annex

The following can be found in the EC Hydrogen Strategy, published on 8 July:

- Priority of hydrogen uses would be given to hard-to-decarbonise sectors such as steel, cement, shipping and aviation;
- Introduction of CCfDs to incentivise the roll-out of dedicated GW sale green hydrogen factories;
- However, while promoting the upscale of renewable hydrogen production & demand in the EU, the strategy allows deployment of low-carbon hydrogen (fossil fuel based hydrogen coupled with CCS) until at least 2030;
- There is a strong focus on renewable hydrogen in principle, with a statement that by 2050 all H2 should be RES H2. New investments should focus on electrolysers. But at the same time the strategy reaffirms what was already in the leak: the role of “low-carbon”, fossil based H2 in the short and medium term (2030 minimum);
- Same timeline as first seen in the leak, so-call **gradual trajectory**, renewable hydrogen is phased in but fossil-fuel hydrogen is not phased out:

    1. **Until 2024**, the focus will be on producing **1 million tonne of RES H2 and have 6 GW** of renewable hydrogen electrolysers in the EU

    2. **Until 2030**, the focus will be to produce **10 million tonne of RES H2 and 40 GW of electrolysers**. Electrolysers are expected to be able to compete with fossil-based hydrogen in 2030: "*In a second phase, from 2025 to 2030, hydrogen needs to become an intrinsic part of an integrated energy system with a strategic objective to install at least 40 GW of renewable hydrogen electrolysers by 2030 and the production of up to 10 million tonnes of renewable hydrogen in the EU.*"

    3. **From 2030 to 2050**, the focus will be on developing H2 technology at a larger scale to reach the hard to abate sectors. RES electricity needs to massively increase as about (one third) of electricity might be used for RES H2 production: " *the share of hydrogen in Europe’s energy mix is projected to grow from the current less than 2%4 to 13-14% by 2050*."

    4. **Towards 2050:** H2 could be deployed at a larger scale to a wider range of sectors of the economy.

- **Investments**: Cumulative investments in renewable hydrogen in Europe could be up to **EUR 180-470 billion by 2050**. And in the range of **€3-18 billion for low-carbon fossil-based hydrogen**;
- No real mention of Energy Efficiency first principle;
- No clarification on the rules and responsibilities surrounding the future hydrogen infrastructure;
- A new Clean Hydrogen Alliance, which lacks climate mandate and science link, no milestones for phasing out fossil gas.

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