FACTSHEET – HYDROGEN

BACKGROUND

The energy transition requires a massive increase in investments. According to the 'Net Zero Emissions by 2050' (NZE) scenario[1] of the International Energy Agency (IEA), which is the most referenced scenario with low or no overshoot and limited reliance on negative emissions technologies, yearly investments in the "clean" energy transition must more than double and reach US$4.2 trillion by 2030. Meanwhile investments in fossil fuels must decrease and any support to their expansion must be stopped immediately. However, the role of certain energy sources and technologies should be nuanced. Consideration is particularly required when development is uncertain or associated with damaging social, environmental and climate impacts or risks, or poses too great a threat to the 1.5°C objective and global biodiversity protection targets.

This document debates the potential of hydrogen in the power sector transition. It is part of a series of factsheets that aim to guide the decisions of financial players wishing to contribute to a rapid and fair energy transition.

Hydrogen is an energy carrier and its production method determines its environmental impact. Currently, it is almost exclusively produced from fossil fuel processing, but it can also be produced from the water-based process of electrolysis. It is a growing topic in the energy transition, often seen as a way to decarbonize hard-to-abate sectors, such as ironmaking and heavy-duty transportation, and sometimes as an opportunity for storage in the power sector. This factsheet addresses hydrogen's production routes and its utilization.

KEY ELEMENT – HYDROGEN PRODUCTION

Hydrogen can be produced from fossil fuel processing, with or without carbon capture (CCUS), or from water-based electrolysis, giving "electrolytic hydrogen".

[1] IEA, World Energy Outlook, 2023.

	Production route	Median carbon emissions[2] (kg CO_2e/kg H_2)	Share of 2021 production[3] (%)
Fossil fuel processing	Coal gasification (without CCUS)	22.7	19%
	Fossil gas (SMR**, POx***) (without CCUS)	11.4 (SMR**) N/A (POx***)	62% (*SMR largely dominant on POx)*
	Coal gasification (with CCUS)	2.6 - 3.1*	0.7%
	Fossil gas (SMR**, POx***) (with CCUS)	3.7 - 6.1* (SMR**) 2.5 (POx***)	
Electro lysis	Solar-based electrolysis	1.35	0.04%
	Onshore wind-based electrolysis	0.6	
	Nuclear-based electrolysis	0.2	

Table 1: Median carbon emissions per kg H2, and share of 2021 production, per hydrogen production route.

Hydrogen obtained as coproduct by naphtha reforming – a stage of oil refining – makes up the remaining 18%.

➢ Production – current and prospects

Currently, most hydrogen is produced from fossil fuels using very carbon-intensive processes, while alternative “low-carbon hydrogen” represents a marginal amount of production (less than 1%), but is growing.[4]

The IEA’s NZE expects strong growth in hydrogen production to meet soaring demand, from 94 Mt in 2021 to 180 Mt by 2030 (+96 Mt). Almost all this growth is met by “low-carbon hydrogen”, two-thirds from water-based electrolysis and one-third from fossil fuels with CCUS,[5] covering more than half of total hydrogen production in 2030. Electrolysis uses machines running on electricity called electrolysers to produce hydrogen from water, while hydrogen produced by fossil fuels with CCUS relies on the addition of CCUS systems to mitigate emissions. Unlike fossil fuels-based processes, electrolysis does not emit greenhouse gases, giving electrolytic hydrogen the smallest carbon footprint.

➢ Hydrogen produced from fossil fuels with CCUS

The possibility of fossil fuels-based routes being “low-carbon” relies on the implementation of CCUS systems to mitigate carbon emissions efficiently, and in the long-term. Currently, however, the indefinite storage of carbon is still an unproven hypothesis. As for efficiency, a 60% CO_2 capture rate[6] leads to almost no climate benefit for energy uses. In other words, burning fossil gas would only generate slightly more emissions than burning the hydrogen produced from it.[7] This is a key point for attention: a case study highlights that Shell’s Quest hydrogen plant, which is based on fossil fuels with CCUS, had a CO_2 capture rate of just 48% in 2021.[8]

Furthermore, CCUS focuses on mitigating direct emissions only, but fossil fuel extraction, processing, and supply also emit CO_2 and methane. For instance, if the rate of gas leaking into the atmosphere along the gas value chain – the methane leakage rate – is 3.5%, burning hydrogen produced from fossil gas

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[2] IEA, Comparison of the emissions intensity of different hydrogen production routes, accessed in July 2023. *Ranges are given for different efficiencies of CCUS systems applied to direct emissions – low bound corresponds to CCUS efficiency above 93% and high bound to CCUS efficiency of 60%. **SMR: Steam Methane Reforming. ***POx: Partial Oxidation. ‘Carbon emissions’ covers direct emissions of production and, for fossil fuel processes and nuclear-based electrolysis, extraction, processing and supply of fuels; for solar and onshore wind, production of solar PV systems and wind turbines.
[3] IEA, Global Hydrogen Review 2022, p.71, accessed in July 2023.
[4] IEA, Global Hydrogen Review 2022, p.75, accessed in July 2023.
[5] IEA, Global hydrogen production by technology in the Net Zero Scenario, 2019-2030, September 2022.
[6] This corresponds to the average capture rate from partial carbon capture. Source: IEA, Towards hydrogen definitions based on their emission intensity, p.46, April 2023.
[7] Ibid. This result considers only direct emissions and ignores upstream emissions.
[8] Global Witness, Hydrogen’s Hidden Emissions, January 2022.

with CCUS would be even more polluting than directly burning fossil gas without CCUS.[9] This assumes an efficient CCUS system with a CO2 capture rate of 85% in the hydrogen production process. Studies have observed similar average methane leakage rates making this a realistic scenario,[10] with the higher methane emissions being related to the consumption of large fossil gas volumes in hydrogen production and in powering CCUS systems.

Hydrogen produced from water-based electrolysis

There are far fewer doubts regarding electrolytic hydrogen and its benefits for the climate, as water-based electrolysis produces no direct emissions. Indirect emissions from electrolytic hydrogen production relate to the electricity needed to power the electrolyser. If a sustainable power source is used, the manufacturing of the power generation systems becomes the main source of emissions, which will be significantly lower than fossil fuels-based production emissions.

Electrolyser capacities were 510 MW at the end of 2021, a 70% growth from 2020.[11] From 2021 to 2022, the pipeline of projects operational by 2030 grew from 54 GW to 134 GW – a 262-fold increase between 2021 and 2030 if all projects successfully reach production.[12] However, financial backing is a key issue. Currently, less than 10% of projects in the pipeline have reached Final Investment Decision (FID), and some past projects have been delayed for failing to secure financing.

Furthermore, to meet the NZE scenario's production targets, electrolytic hydrogen production capacity should reach 720 GW[13] to 850 GW.[14] As such, the current project pipeline of 134 GW is insufficient.

More electrolyser manufacturing plants are needed to increase manufacturing capacity in line with the NZE.[15] At the end of 2022, it was possible to build 30 GW of new electrolysers per year, limiting the size of the electrolytic hydrogen pipeline. Even when accounting for electrolyser manufacturing projects that will start operation by 2030, electrolytic hydrogen production capacity will be capped around 300 GW by 2030 without additional manufacturing capacity – well short of the NZE's 720 GW target. To achieve this milestone, it is therefore necessary to build new electrolyser manufacturing capacity to keep up with the NZE planned level of electrolyser deployment.

KEY ELEMENTS – HYDROGEN DEMAND

The NZE expects a strong growth in hydrogen demand by 2030,[16] mainly driven by new uses. Hydrogen can help decarbonize ironmaking, using hydrogen-based Direct Reduction of Iron (DRI) to remove metallurgical coal from the ironmaking process,[17] and it can replace fossil fuels in heavy duty transportation. It can also be transformed into hydrogen-based fuels, such as ammonia, and can provide long-term storage in electricity systems.[18]

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[9] Robert W. Howarth, M. Z. Jacobson, How green is blue hydrogen?, August 2021: using a 20-year time frame for converting methane emissions in CO2-equivalent.
[10] Robert W. Howarth, Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy, October 2015.
[11] According to the IEA's Global Hydrogen Review 2022, the electrolytic hydrogen production capacity was set to double, or triple, compared to 2021 levels by the end of the year.
[12] IEA, Global Hydrogen Review 2022, p.75, accessed in July 2023.
[13] IEA, World Energy Outlook 2022, p.136, October 2022.
[14] IEA, Global Hydrogen Review 2022, p.79, accessed in July 2023.
[15] Ibid.
[16] Same as its expectations for production.
[17] Reclaim Finance, Metallurgical coal financing report, November 2023.
[18] IEA, World Energy Outlook 2022, October 2022. Other uses exist but are marginal in the NZE – less than 10% by 2030 and less than 5% by 2050 – and are therefore not presented here.

However, all the new demand may not be met: a third of new production would need to be met by fossil fuels with CCUS, which should not be developed given its climate impact, while the remaining two-thirds would rely on a strong growth of the electrolytic hydrogen production, which is uncertain. Consequently, the uses of "low-carbon hydrogen" must be prioritized.

According to the IEA,[19] the relevance of hydrogen to the energy transition is "very high" in the ironmaking industry and in shipping through the development of ammonia as a hydrogen-based fuel in particular. It is also "high" for heavy road transportation. For the power sector, the relevance of hydrogen is only "moderate". While hydrogen is attractive in its ability to store energy, with the possibility of bringing flexibility to power networks and supporting the integration of variable renewable energy, the power and heat sectors are in fact easier to abate via alternative solutions that already exist for implementation.[20]

RECLAIM FINANCE'S POSITION

On hydrogen production:

Reclaim Finance is not in favor of supporting hydrogen production using fossil fuels, with or without CCUS. Producing hydrogen using fossil fuels is highly carbon intensive and CCUS has no positive impact on the climate, and even a negative impact, compared to traditional use of fossil fuels. Financial institutions should not include hydrogen produced from fossil fuels in their energy transition financial and capacity targets, or in their energy transition frameworks.

Instead, financial institutions should focus their support on electrolytic hydrogen, which is the only form of hydrogen compatible with a fossil fuel-free energy system.[21] In our view, it is the only hydrogen that can be labelled "sustainable", provided it is produced using sustainable power.

While the current pipeline of electrolytic hydrogen projects is significant, it needs to drastically increase. Even so, the gap with the planned capacity for 2030 in the NZE seems unlikely to be closed. Financial support is critical; Reclaim Finance recommend actively supporting the development and deployment of electrolytic hydrogen projects. To enable this at the required scale, electrolyser manufacturing capacity must additionally increase; we recommend actively supporting these projects.

On hydrogen demand

Reclaim Finance is not in favour of supporting the use of hydrogen for power storage or heating. Though hydrogen could bring benefits to power systems as a storage solution and help integrate variable renewable energy, other hydrogen-free solutions can provide this service more efficiently.[22]

Considering the few decarbonization options available to some sectors and the strong competition for hydrogen, financial institutions should support the development of hydrogen-based transition solutions for specific hard-to-abate sectors, such as the hydrogen-based Direct Reduction of Iron and the use of hydrogen-based fuels in long distance transportation, primarily shipping.

[19] IEA, Clean Energy Technology Guide, accessed in July 2023.
[20] See factsheet on energy storage.
[21] For a definition of sustainable power see: Reclaim Finance, The limits of (not so) clean energy, October 2023.
[22] See Reclaim Finance's factsheet on energy storage.