Climate Action Network

Position Paper: Renewable-based hydrogen

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Climate Action Network (CAN) is a global network of more than 1,900 civil society organisations in over 130 countries driving collective and sustainable action to fight the climate crisis and to achieve social and racial justice.

Summary

- CAN only supports renewable-based hydrogen and its derivatives produced by electrolysis, powered by solar and wind energy primarily, provided that its production respects and protects the environment and human rights[1].

- CAN opposes any hydrogen production and use derived from fossil fuels (with or without carbon capture and storage) or nuclear energy, because these methods of production are fraught with risks to the climate, the environment and to human rights.

- CAN opposes any type of hydrogen (or any of its derivatives, e.g. ammonia) blending as well as combustion with fossil fuels, which will only extend fossil fuels and delay the necessary transition towards renewables.

- CAN recognises the many social, human rights, land rights, water rights, economic, trade and environmental challenges associated with the build out of renewable hydrogen infrastructure and its expansion as an export commodity, particularly in the Global South and in other areas prone to extractivist dynamics. CAN therefore demands that as part of a Just Transition across all sectors, sustainable, equitable, human rights compliant measures, policies and practices are put in place and fully respected wherever renewable-based hydrogen is being produced, transported or used.

- On the pathway to 100% renewable energy systems, it is imperative not to prioritise the deployment of renewable energy for hydrogen, the use of which will be limited to very targeted applications. The priority is to phase out all fossil fuels and decarbonise the power sector with renewables and, in the Global South, ensure access to energy for all.

- Energy sufficiency measures, particularly in rich countries, as well as energy efficiency measures should be prioritised to minimise energy and hydrogen demand (e.g. through tackling overconsumption and reducing energy demand for transportation as well as

[1] As per CAN's position on a just, rapid and equitable transition to 100% renewable energy.

material such as steel, plastics and fossil fuel-based fertilisers). Direct electrification should be used whenever possible to minimise the demand for hydrogen.

- CAN is supportive of renewable-based hydrogen as a feedstock or energy carrier in a limited number of applications where it is the most economically and technically viable option, and socially and environmentally sound. This includes the use of renewable hydrogen to replace fossil fuel-based hydrogen in industry - in line with a just and equitable phase out of all fossil fuels -, and as a storage solution to provide flexibility to power systems when insufficient renewables are available in the grid system or for renewable power trading.

- In the transport sector, and emphasising that the priority should be to reduce transportation needs and develop public transport, CAN acknowledges that renewable hydrogen and hydrogen-derived fuels have the potential to contribute to the decarbonization of sectors that are presently hard to electrify such as long-haul aviation and shipping, although these remain yet-to-be-proven options. CAN is pushing for research and measures to minimise the impacts associated with the production of such fuels as well as energy consumption (e.g. more efficient technologies and behavioural changes such as reduced air travel). CAN opposes the use of hydrogen for light duty and other vehicles that can be electrified.

- CAN promotes a transparent, independently verified certification system of the origin of all hydrogen sold, used and traded for all consumers.

Introduction

Hydrogen is currently almost exclusively produced from fossil fuels (>99%[2]) and is mainly used as a raw material in a handful of energy-intensive industrial sectors like oil refining, fertilisers, methanol, iron and steel[3].

For around three decades, there has been a growing interest in hydrogen and its derivatives (such as ammonia and synthetic fuels). This has led to frequent spikes of a "hydrogen hype" where hydrogen is often presented as a silver bullet for decarbonisation (e.g. for power generation, cars or heating boilers) by companies with vested interests in continuing using fossil fuels or nuclear electricity to produce "low-carbon hydrogen"[4]. And yet, so far, the lack of economic and technological viability has not resulted in any real uptake of either renewable or "low-carbon" hydrogen. For instance, when producing hydrogen from electrolysis, energy

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[2] IEA (2023), Global Hydrogen Review, p. 64. In 2022 natural gas without CCUS accounted for 62% of global production, followed by coal (21%) and hydrogen being produced as a by-product in refineries and petrochemical industry (16%).
[3] IEA (2023), Global Hydrogen Review, p. 21. Of the 53 Mt of hydrogen used in industry in 2022, about 60% was for ammonia production, 30% for methanol and 10% for DRI in the iron and steel subsector.
[4] See e.g. https://www.hydrogeninsight.com/power/opinion-greenwashing-madness-as-low-carbon-ammonia-shipped-from-saudi-arabia-to-japan-to-be-burned-at-oil-refinery/2-1-1439012, https://www.hydrogeninsight.com/power/jera-to-start-co-firing-20-grey-hydrogen-based-ammonia-at-coal-fired-power-station-this-month/2-1-1611993

conversion losses are over 25%[5] and are higher when producing hydrogen derivatives like ammonia and other synthetic fuels.

But with the decline in wind and solar investment costs observed in recent years, combined with technology improvements and the urgent need to reduce greenhouse gas (GHG) emissions for a 1.5 C pathway, demand for hydrogen is expected to increase, e.g. from 100 Mt in 2022 to 450 Mt in 2050 in the latest IEA's Net Zero Emissions by 2050 (NZE) scenario[6]. CAN notes that in the IEA and IRENA's global scenarios (which includes nuclear-based and fossil fuel-based hydrogen, as well as hydrogen uses not supported by CAN), hydrogen and hydrogen derivatives will only represent around 13-14% of total final energy consumption[7].

There are, however, growing concerns around its actual potential in a decarbonised world. In many sectors, direct electrification is feasible and more efficient than the use of hydrogen as an energy carrier. The IEA estimates that only 7% of planned renewable capacity for hydrogen production for the decade would effectively come online by 2030[8]. Additionally, there are concerns around the socio-environmental impacts associated with hydrogen production and trade, including for example on water use as well as human and land rights.

Different colours are commonly used to refer to hydrogen produced through various processes (electrolysis, steam-methane reforming) and from various sources of energy (methane, nuclear or renewable electricity, etc.). However, this colour-coded nomenclature can be vague and does not cover all cases (e.g. electrolytic hydrogen from grid electricity). In this position, the use of colour-coded terms is therefore avoided and the term "**renewable-based hydrogen**" is used in place of "green hydrogen".

[5] https://h2sciencecoalition.com/blog/hydrogen-for-heating-a-comparison-with-heat-pumps-part-1/

[6] IEA (2023), Net Zero Roadmap. In this scenario, new demand comes mainly from the transport and industry sectors.

[7] Hydrogen and hydrogen-derived fuels represent 14% of final energy consumption by 2050 in the latest 1.5 -aligned scenario by IRENA (2023, World Energy Transition Outlook) and 13% in the IEA's Net Zero Scenario (IEA 2021, Net Zero by 2050, p.105). For comparison, in the PAC scenarios developed by CAN Europe, hydrogen and hydrogen derivatives represent 17% of total final energy consumption in the EU in 2040. As a rule of thumb, countries with comparably higher rates of heavy and energy-intensive industries will need more renewable hydrogen for a 2050 net-zero decarbonisation.

[8] IEA (2024), Renewables 2023

This paper proposes principles for responsible, sustainable, and adequate production and use of hydrogen and hydrogen derivatives

1. Energy savings, sufficiency and renewable energy-based electrification need to be aligned. In line with its previous positions on energy efficiency[9], CAN reaffirms that when it comes to mitigation, energy efficiency and demand-side reduction measures are as important as the upscale of renewable energy. Material demand reduction through sufficiency measures and circular economy should also be prioritised. For hydrogen-consuming sectors, this includes for example: a) in agriculture: a reduced use of nitrogen/ammonia fertilisers to align with agroecological practices; b) in industrial sectors: reduced production and use of plastic and steel products, improved efficiency in production processes, increased material substitution, higher recycling rates and strong circularity measures to prioritise recycled products in the steel industry notably, etc.; c) in the transport and land planning sectors: public transportation and ride-sharing, modal shift away from private vehicles towards more walking, cycling, micro-mobility, air travel demand reduction, lower demand for shipping transport through the relocalization of economies, ban of cruise ships, use of electrified ferries, etc.

Further, when technically viable, direct electrification is far more efficient and cost-effective in its use of renewable power and should be prioritised over the use of hydrogen and hydrogen derivatives, such as in the cases of home heating, water heating, power generation and road transport. This would minimise the risks associated with hydrogen production, storage and transport, and would avoid energy conversion losses.

2. Renewable-based hydrogen only. In sectors where hydrogen is used in ways consistent with this CAN position, CAN only supports hydrogen produced via electrolysis from renewable sources of electricity, primarily solar and wind. Hydrogen derivatives such as ammonia, methanol and other synthetic fuels must also be produced from renewable-based hydrogen.

Hydrogen must not be produced from, blended or combusted with fossil fuels, with or without Carbon Capture and Storage (CCS)[10]. As per its position on nuclear energy[11], CAN strictly opposes hydrogen produced from nuclear electricity. CAN also opposes hydrogen being produced from the use of woody forest biomass as a feedstock (through gasification) or energy source for electrolysis, and reiterates that large-scale bioenergy with CCS "would result in unacceptable negative impacts on food security, land use rights, and biodiversity"[12]. Renewable hydrogen should also not be combusted with fossil fuels.

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[9] CAN's position on Global targets for RE and Energy efficiency and CAN position on Energy efficiency and conservation.

[10] CAN's position on Carbon capture, utilisation and storage.

[11] CAN's position on Nuclear power.

[12] CAN's position on Carbon capture, utilisation and storage.

Renewable electricity generation for hydrogen should not be detrimental to the efforts needed to decarbonise the power sector and provide energy access to all. On the pathway to 100% renewable energy systems, it is imperative not to prioritise the deployment of renewable energy for hydrogen production. The priority is to phase out all fossil fuels and decarbonise the power sector with renewables and, in the Global South, ensure access to energy for all.

The production of hydrogen by companies or governments, whether it is for industrial processes and/or storage for power production, should be accompanied with *additional* renewable electricity to be fed to the national grid. Depending on the jurisdiction, this additionality component may be made more stringent by adding temporal (e.g. hourly or intraday matching) and geographical correlations criteria[13].

In the Global South in particular, the deployment of renewable energy for hydrogen should not delay or prevent the uptake of renewable energy that is necessary to increase electrification rates and overcome energy poverty. When deployed, hydrogen infrastructure should support mini-grid and off-grid renewable uptake as appropriate.

3. Hydrogen produced from, blended or combusted with fossil fuels must not be considered a "transition fuel" or a path to decarbonization. The use of hydrogen or its derivatives alongside fossil fuel, e.g. for blending in gas networks or co-firing in coal or gas power plants, is more often than not presented as a measure by governments and fossil fuel industries to supposedly kick-off the production of renewable hydrogen or with the promises of ultimately switching to renewable hydrogen only (or in the case of ammonia-coal co-firing, eventually mono-firing 100% ammonia). This is for example the case in Japan, which is strongly pushing for ammonia-coal co-firing as part of its national strategy and also pushing for this technology throughout Southeast Asia and South Asian countries[14].

On the contrary, continued or new investments in fossil-fuel based hydrogen or hydrogen blending or co-firing will only lock countries into unsustainable energy systems and delay the upscale of renewable energy, while having limited emissions reductions potential[15]. CAN therefore strongly opposes hydrogen blending as well as co-firing with hydrogen or hydrogen derivatives such as ammonia in coal or gas power plants, with or without CCS.

Consequently, **CAN also opposes the development of infrastructure deemed as "hydrogen-ready"** such as LNG terminals, pipelines, gas-fired plants or boilers, as this risks delaying the transition out of fossil gas. In addition, due to the different characteristics of gas and hydrogen or hydrogen-derivatives (e.g. density, boiling points, corrosion), repurposing gas infrastructure presents economical and technical challenges and is fraught with uncertainties[16].

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[13] See e.g. in the US (https://www.evolved.energy/post/45v-three-pillars-impact-analysis) and proposals in the EU: Transport and Environment (2021), How to ensure the sustainability of electrofuels)
[14] https://www.ammoniacoalfiring.info/
[15] See e.g. Fraunhofer (2022), The limitations of hydrogen blending in the European gas grid.
[16] See e.g. https://www.nrdc.org/bio/ade-samuel/hydrogen-ready-lng-infrastructure-uncertain-way-forward and IEA (2022). Global hydrogen review 2022, p.145 - 150.

4. All renewable-based hydrogen production, storage, transport and use should follow the highest social, human rights, environmental and sustainability standards, including protection of the right to a clean, healthy and sustainable environment. Governments and industries must ensure that all emissions throughout the entire value chain are taken into account when designing regulations, certifications and standards for (renewable) hydrogen. Emissions must also be regularly inventorised and monitored, with the objective of minimising them: this includes CO_2 emissions and H_2 emissions/leakages across the whole supply chain. Hydrogen is an indirect greenhouse gas that reacts with chemicals in the atmosphere, resulting in increases in tropospheric ozone, water vapour and methane, which are all warming gases[17]. Its global warming potential on a 20 year timeframe could be as high as 44 and about 12 times higher than CO_2 per unit over 100 years[18]. NO_x emissions occurring during combustion should be monitored and curtailed, due to their negative impacts on health and as NOx are indirect greenhouse gases. Any certification must be done by independent entities and data must be transparent and verifiable[19].

Because of its high volatility, flammability and permeability, high safety standards must be upheld for the transport, storage and use of hydrogen and its derivatives (ammonia, methanol). Ammonia is also toxic to humans (exposure to high levels can cause blindness, lung damage and even death) and marine environments[20].

In addition to the risks of leakage and the safety concerns, the transportation of hydrogen and its derivatives is costly and entails large energy conversion losses (since it needs to be in the form of liquid hydrogen, ammonia or liquid organic hydrogen carriers)[21]. The round trip efficiency of converting hydrogen to ammonia and back to hydrogen can be as low as 20%[22]. The transportation of hydrogen over long distances should therefore be kept to an absolute minimum, and the production of hydrogen near its point of consumption should be encouraged.

The production of renewable-based hydrogen will entice an increased demand for resources such as additional land use for wind and solar installations, carbon for the production of some hydrogen-derived synthetic fuels like methanol, water for electrolysers, minerals for wind and solar plants as well as electrolysers and fuel cells. Although the overall environmental and land use challenges of enhanced wind and solar power expansion are limited compared to the social, economic, environmental and developmental impact of fossil fuels and nuclear power[23], the highest social, human rights, environmental and sustainability standards should be applied.

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[17] Sand et al. (2023), A multi-model assessment of the Global Warming potential of hydrogen.
[18] Warwick et al. (2022), Atmospheric implications of increased Hydrogen use; Sand et al. (2023), A multi-model assessment of the Global Warming potential of hydrogen.
[19] For an analysis of certification schemes, see IRENA (2023) - Creating a global hydrogen market: Certification to enable trade.
[20] Oeko-Institut (2021), Ammonia as a shipping fuel, risks and perspectives.
[21] https://www.nrdc.org/bio/ade-samuel/hydrogen-ready-lng-infrastructure-uncertain-way-forward
[22] https://www.hydrogeninsight.com/transport/-world-first-on-board-ammonia-cracker-for-hydrogen-fuel-now-operating-on-spanish-vessel/2-1-1559004
[23] REN21 (2024), Renewable Energy and Sustainability Report

- Effective civil society inclusion and participation should be ensured, from the early stages of the project throughout its life cycle.
- Land rights and rights of communities, including Indigenous peoples, affected by hydrogen-related infrastructure (electrolysers, desalination plants, wind and solar farms) should be duly respected, including but not limited to the principle of free, prior and informed consent of local land users[24]. This is essential to uphold environmental justice, because fenceline communities, often of colour and lower incomes have historically been disproportionately harmed by the biased siting of energy infrastructure in "sacrifice zones". It must be assured that hydrogen buildout will not perpetuate the same injustices.
- With regards to water, for every kilogram of electrolytic hydrogen, about 9 kg of purified water are required for the electrolysis process itself. Water is also required for cooling and can represent up to 56% of total water withdrawal of electrolytic hydrogen facilities[25]. While renewables-based hydrogen already uses less than 30% to 50% of freshwater per unit of energy than fossil fuels or/and hydrogen produced from fossil fuels[26], water demand for hydrogen should be reduced to the maximum extent possible. In addition, the use of water for hydrogen production should not negatively impact the right to water and sanitation by depleting the fresh water supply, exacerbating water stress or resulting in competition over local water use between e.g. industry and households. This is particularly important as more than one-third of renewable-based or "fossil fuel + CCS"-based operating and planned hydrogen production capacities are located in already highly water-stressed regions[27]. The use of water should be thoroughly assessed through e.g. water impact assessment, comply with water regulations and be minimised through more efficient facilities and production methods[28]. When seawater is used, *additional* desalination plants should be built where necessary and should benefit local communities as well. Brine management and disposal should be dealt with in compliance with human rights and sustainability standards.

5. Adequate and targeted uses of hydrogen. The role of renewable-based hydrogen should be restricted to "no-regret" sectors, where direct electrification is not yet technically possible and after implementing demand-side and energy efficiency measures to minimise energy demand. However, in certain end-use applications, the relative GHG emissions reductions and economic benefits of hydrogen over other technologies are still uncertain, such as high temperature industrial processes (e.g. in the cement sector[29]) and certain modes of transport. Further studies are needed to identify where hydrogen is the most technically, economically and/or environmentally appropriate solution, and where alternative technologies are more effective, including direct electrification and/or alternatives that reduce or eliminate the need for hydrogen, such as electrolytic reduction in the steel sector.

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[24] See CAN's position on "The transition to 100% renewable energy must be just, equitable and rapid"
[25] IRENA (2023), Water for hydrogen production
[26] https://www.versogen.com/does-the-green-hydrogen-economy-have-a-water-problem/
[27] IRENA (2023), Water for hydrogen production
[28] Ibid.
[29] IRENA (2022), Green Hydrogen for Industry

Industry: Priority should be given to replacing fossil-fuel based hydrogen with renewable-based hydrogen in industrial sectors where hydrogen is currently used as a feedstock and where direct electrification is not yet possible (petroleum refineries, ammonia, methanol and steel). However, the need for and amount of renewable-based hydrogen in such sectors should be thoroughly assessed and planned, and has to be compliant with a just and equitable phase out of all fossil fuels, as well as a reduced dependency on and phase out of emission-intensive chemical fertilisers, in parallel to the development of agroecology practises.

Renewable-based hydrogen is particularly expected to play a greater role in the decarbonisation of the steel sector (responsible for up to 4% of global CO2 emissions) by replacing coking coal[30], through the hydrogen direct reduced iron production route[31].

Power sector: For a 100% renewable energy future across all economic sectors, a 100% renewable power sector is a precondition. CAN promotes wind and solar as key technologies to achieve 100% renewable electricity. As these technologies are variable and weather-dependent, and there will be periods of excess generation during windy or sunny months or seasons (already observed in several European countries), the deployment of storage solutions to store excess electricity will be required to avoid losses. For short to medium term storage, different options exist such as batteries (for lower capacities), hydro-pumped storage, Compressed or Liquid Air Energy Storage (CAES / LAES) and gravity-based storage solutions. The use of hydrogen is one option to be considered alongside others, depending on communities' prior and informed consent, local infrastructure and needs, etc. For long-term or seasonal storage of electricity, renewable-based hydrogen is also a potential option[32], although the safety, environmental and human rights impacts of considered storage solutions (salt caverns, old unused fossil gas tanks, depleted aquifers etc.) will have to be duly assessed and taken into consideration.

Transport: As stated above, CAN prioritises the implementation of energy efficiency and sufficiency measures in the transport sector through various measures, including but not limited to a reduced demand from the aviation and shipping sectors and freight in general.

- For land transport, light duty electric vehicles are far more efficient and becoming cheaper than vehicles based on direct hydrogen combustion or fuel cells and should therefore be prioritised. In transport segments where electrification is more challenging (e.g. due to batteries' weights and space requirements, charging infrastructures, etc.), fuel cells could play a role. For heavy duty vehicles like buses, large trucks and heavy machinery, it remains unclear whether batteries or hydrogen fuel cells will provide the best solution. If advances in battery technology result in viable alternatives to fuel cells,

[30] Metallurgical coal in the steel-making production process has a higher carbon content and lower amounts of other ingredients than regular coal

[31] https://www.visualcapitalist.com/sp/green-steel-decarbonising-with-hydrogen-fueled-production/

[32] IPCC AR6 WGIII, Mitigation of Climate Change, Table 6.5. See also e.g. Maestre et a. (2021), Challenges and prospects of renewable hydrogen-based strategies for full decarbonization of stationary power applications

these would be preferable to fuel cells given their better efficiency. However, rail transportation should be prioritised when possible.

- In the aviation and maritime sectors, electric aircrafts or vessels are not yet commercially available and are not foreseen to be used for long-distance trips in the near-term[33]. Renewable-based hydrogen and hydrogen-derived fuels (e.g. ammonia, methanol, renewable e-kerosene) have the potential to contribute to the decarbonization of the shipping and aviation sectors, notably for long-haul travel. For example, renewable-based ammonia is likely to play a growing role in the future for commercial shipping and long-distance freight transport[34], although it entails many risks[35] (e.g. toxicity to marine life). In the aviation sector, for long-haul flights, the use of e-kerosene produced from renewable hydrogen is systematically considered in decarbonisation scenarios[36].

  However, the production of these e-fuels require large amounts of renewable electricity (including considerable land use), and are associated with important conversion losses and cannot be seen as a "silver bullet". CAN recognizes that their potential use worldwide is presently very limited, will not contribute to deep GHG emissions reductions in the near future, and that their economic viability remains unpromising. Reduced demand e.g. for air travel should could come first, while energy efficiency solutions (e.g. speed reduction) as well as alternative/additional technological solutions (e.g. wind-powered cargo ship[37]) should be further researched and deployed.

Buildings: In the building sector, in addition to strong refurbishment towards low/zero energy housing, using electric heat pumps is much more efficient for heating and cooling than using hydrogen via existing gas supply infrastructure and should therefore be prioritised[38]. The use of hydrogen for heating in residential buildings also comes with high costs for consumers[39].

6. If pursued, the trade of hydrogen and hydrogen derivatives should be fair and sustainable, and benefit local communities as well as countries' domestic economies[40].

Hydrogen trade is anticipated to be predominantly local or regional rather than international[41], because hydrogen is not a commodity that can be easily transported, and unlike fossil fuels, it can be produced where it is needed (making local production more economically sound).

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[33] ICCT (2022), Performance analysis of regional electric aircrafts; ICCT (2018), Beyond road vehicles: survey of zero-emission technology options across the transport sector.

[34] EMSA (2021), Potential of Ammonia as Fuel in Shipping; Global Maritime Forum (2022), Ammonia as a shipping fuel.

[35] Oeko-Institut (2021), Ammonia as a shipping fuel, risks and perspectives.

[36] See e.g. https://theicct.org/stack/net-zero-aviation-mar22/ (global) or Transport & Environment (2022), Roadmap to carbon neutral aviation in Europe (Europe)

[37] https://projects.research-and-innovation.ec.europa.eu/en/horizon-magazine/ships-harness-wind-voyage-cleaner-future

[38] https://h2sciencecoalition.com/blog/hydrogen-for-heating-a-comparison-with-heat-pumps-part-1/

[39] BEUC (2022), The Consumer Costs of Decarbonised Heat.

[40] Heinrich Böll Foundation and Bread for the World (2022), Green Hydrogen: Key success criteria for sustainable trade & production.

[41] IRENA (2022), Global Hydrogen Trade Outlook.

However, CAN observes an increasing number of international trade announcements, which carry the risk of creating new trade and revenue dependencies as well as investments becoming stranded if the future hydrogen export demand does not meet current and uncertain projections. According to the IEA, in 2023, two thirds of the announced trade projects by 2030 have not yet identified a destination country[42].

In addition, the potential negative impact of hydrogen projects on land, water and local economic activities may create or exacerbate tensions between local communities and governments or developers, especially if the hydrogen projects intended for exports do not benefit local communities. This should be acknowledged through specific strategies such as consultations with local communities and participative governance mechanisms or instances.

If international hydrogen trade is to be pursued, in particular between developed and developing countries but also between countries with different economic profiles, the focus should be on exporting higher-value hydrogen-based products further down the value chain[43], such as steel, and on developing sustainable industrial strategies for local use in order to increase the socio-economic benefits for local communities and exporting countries.

[42] IEA (2023), Global Hydrogen Review, p. 104.
[43] Heinrich Böll Foundation and Bread for the World (2022), Green Hydrogen: Key success criteria for sustainable trade & production.