Future Cleantech Architects

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# In Brief: Hydrogen Guardrails

## Guiding Hydrogen Deployment for Industrial and Heavy Transport Decarbonization

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# INTRODUCTION & THE STATE OF HYDROGEN IN EUROPE

Hydrogen is an indispensable industrial feedstock for many crucial industries such as fertilizers (ammonia) and fuels production. Hydrogen could also be used in a wide range of other industries, and help decarbonize them.

A case in point is steel, for which demand in Europe was expected to reach 140 Mt in 2024. At minimum 7.5 Mt of hydrogen—equivalent to 95% of current European hydrogen consumption—would be required to meet this demand using hydrogen in the direct reduced iron (DRI) route, In order to achieve the full decarbonization potential and emissions reductions of up to 97% compared to traditional steel production, clean hydrogen would be required, i.e. hydrogen produced using renewable electricity or carbon, capture and storage (CCS).

Today, hydrogen production remains predominantly from fossil fuels, mostly through natural gas followed by coal. This carbon-intensive process has a significant climate impact: Hydrogen's annual emissions amount to ~1.3 Gt of $CO_2$eq, or ~2.5% of global emissions. Only a symbolic volume of hydrogen, less than 1%, is clean hydrogen.

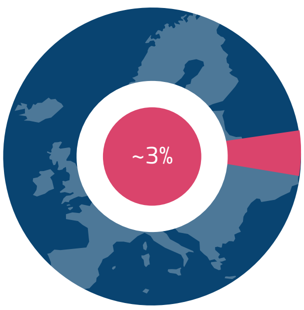
Hydrogen is predominantly used in refineries (~58% of European demand), ammonia production—mainly for fertilizer synthesis—(~25%), and methanol and other chemicals (~11%).

Almost all of European hydrogen production, ~96%, is still from unabated fossil fuels, mainly through natural gas. Hydrogen production accounts for up to 3% of the EU's annual emissions and clean $H_2$ can only meet a minimal fraction of today's European demand.

- Over 550 hydrogen production sites are currently operational in Europe, with a total production capacity of 10.8 Mt/year. More than 95% of that is produced from fossil fuels.
- Over 50% of this production is concentrated in six EU countries: Germany, Netherlands, Poland, Spain, Italy, and France.
- Germany is Europe's largest hydrogen consumer and producer, with an estimated demand of approximately 1.4 Mt per year in 2023.

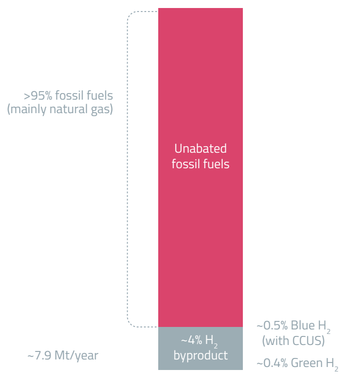
$H_2$ Production is emissions-intensive and contributes ~3% of European $CO_{2eq}$ emissions

Estimated share of European hydrogen emissions per year



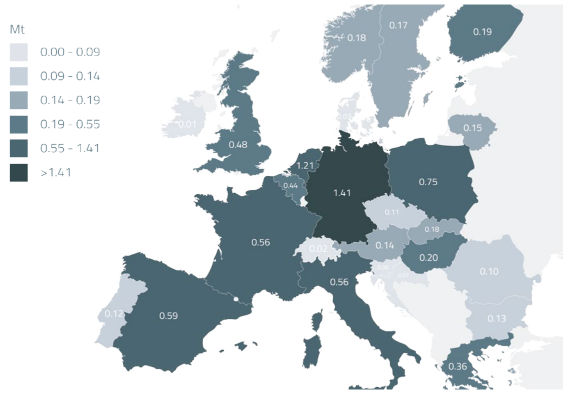

Currently, $H_2$ is primarily produced from fossil fuels. Low-carbon $H_2$ can only meet a minimal fraction of today's European demand.

Hydrogen production pathways in the EU



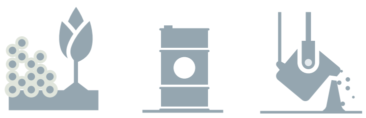

Over 50% of the EU production is concentrated in Germany, Netherlands, Poland, Spain, Italy, and France. Germany is Europe's largest hydrogen consumer and producer.

Hydrogen production per country




Sources: Hydrogen Europe, *Clean Hydrogen Monitor 2024*, and FCA analysis.

# PRIORITIZING HYDROGEN

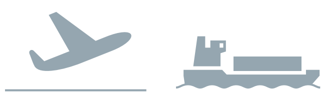


Chemicals: Fertilizers

Oil &Gas

Iron & Steel

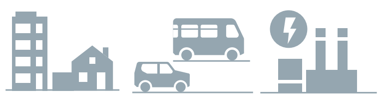
Clean hydrogen will continue to remain scarce in the near future because it relies on the availability of clean electricity and CCS infrastructure[1]. Therefore, hydrogen must first be prioritized for sectors that are currently or will be dependent on it as a feedstock, such as refineries, chemicals, and steel.



Aviation

Shipping

Hard-to-abate sectors with limited direct electrification potential, such as aviation and shipping, should receive priority access to clean hydrogen only once hydrogen-dependent sectors have transitioned to clean hydrogen, or when clean hydrogen is available in such abundance that it allows including these sectors.



Buildings

Road transport

Power generation

Road transport, buildings, and power generation should be excluded from hydrogen deployment strategies or public funding support. That is because direct electrification brings about the most effective emissions savings with the lowest carbon abatement costs in these cases.

[1] Low-carbon hydrogen produced from natural gas, with high carbon capture rates and strict controls on methane emissions, relies heavily on the availability of infrastructure to capture and transport carbon to suitable geological storage sites. Alternatively, the captured carbon could be utilized in processes where it remains permanently stored and not released into the atmosphere. However, low-carbon hydrogen is expected to remain scarce in the near future unless the necessary infrastructure is developed and supportive policy measures are introduced to bridge the commercialization gap. A significant concern is the volatility of gas prices, which creates uncertainty for investors and hampers the deployment of these technologies.

## HYDROGEN GUARDRAILS FOR HYDROGEN DEPLOYMENT IN NON-PRIORITY SECTORS

Several studies suggest that sectors such as buildings, road transport, and power generation, which do not currently use hydrogen, are expected to do so in a decarbonized future. However, these sectors have more effective and readily available decarbonization solutions (e.g., electrification). **These solutions should be opted for to maximize emissions savings and ensure hydrogen is both readily available and prioritized for those essential and hard-to-abate sectors outlined in the previous sections.**

When designing public policy frameworks to support hydrogen development and deployment in non-priority sectors, the following guardrails should be applied. **If the assessments reveal that hydrogen results in the highest total carbon abatement cost and an inefficient use of clean energy, policymakers should avoid allocating public funds to hydrogen in those sectors to ensure a responsible and efficient use of public resources and clean energy.**

### Buildings

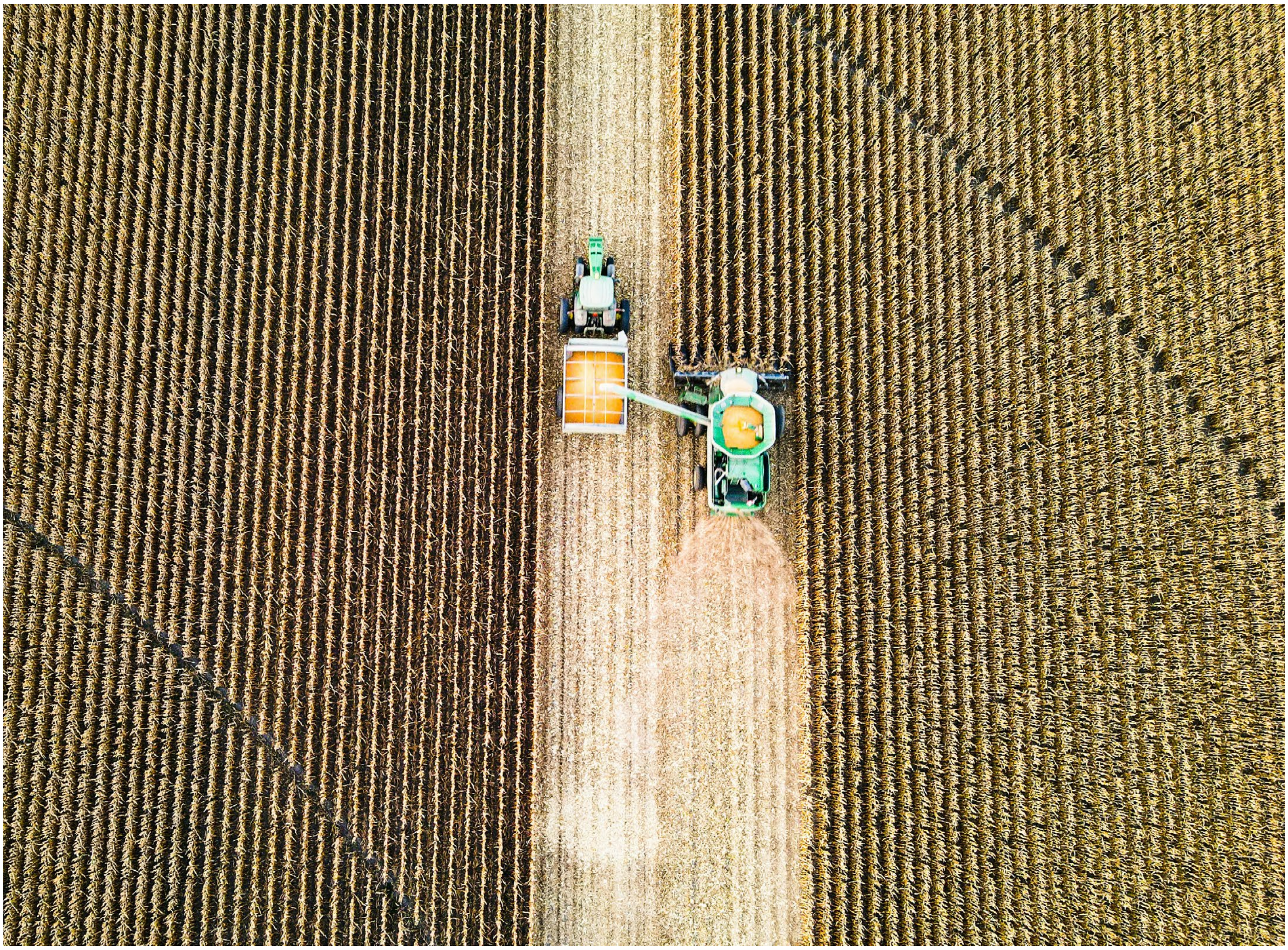
A techno-economic analysis, based on the levelized cost of hydrogen (LCoH), lifecycle GHG emissions reductions, and the total carbon abatement cost of deploying hydrogen versus heat pumps should be included in any public policy framework that seeks to support hydrogen deployment to decarbonize buildings.

### Road transport

A detailed analysis, based on the total cost of ownership of the vehicle, lifecycle analysis, and the total carbon abatement cost of deploying hydrogen versus direct electrification should be included in any public policy framework that seeks to support hydrogen deployment to decarbonize road transport.

### Electricity generation

A techno-economic analysis, based on the levelized cost of electricity (LCoE), lifecycle emissions reduction, and the total carbon abatement cost of deploying hydrogen versus direct electrification should be included in any public policy framework that seeks to support hydrogen deployment to decarbonize the grid of the economy.



## RECOMMENDATIONS

### 1. Decarbonize current hydrogen uses

- Clean hydrogen's critical role in facilitating emissions reductions in sectors such as refining, chemicals, and steel must be prioritized. A facts-based allocation of scarce resources, such as renewable electricity and green hydrogen, that prioritizes sectors currently dependent on hydrogen is key. Ramping up renewable electricity deployment to bring down green hydrogen costs and supplementing supply with low-carbon and novel hydrogen sources can help reduce bottlenecks. It is necessary to assess the feasibility of decarbonizing existing hydrogen production assets through the deployment of carbon capture and storage paired with strict methane emissions control.

### 2. Prioritize hard-to-abate sectors

- Clean hydrogen will play a key role in sectors in which direct electrification is not a viable decarbonization option, such as long-haul aviation and shipping. In these sectors, hydrogen will be used as a feedstock for the production of sustainable alternative fuels. Clear national strategies for clean hydrogen deployment are needed that prioritize hard-to-abate sectors, with targets that provide long-term visibility for hydrogen and alternative fuels coupled with incentives to close the commercialization gap.

### 3. Abandon incompatible sectors

- Science-based guardrails are needed to prevent the use of hydrogen in sectors where other more effective and efficient decarbonization strategies can be deployed (e.g., road transport, heating). To this end, national strategies should exclude hydrogen-incompatible sectors and avoid technology openness in sectors where effective decarbonization solutions such as direct electrification have been established. Awareness must be raised amongst all stakeholders on the challenges and limitations of clean hydrogen.

### 4. Invest in RD&D

- Investing in RD&D is crucial to closing the commercialization gap and ramping up clean hydrogen production to help meet current and future hydrogen needs. It is crucial to fund commercially viable clean hydrogen production pathways, invest in innovative supplementary pathways, and accelerate RD&D to overcome upstream challenges, and ensuring public funds are invested in hydrogen projects that will supply hydrogen to industries where it is an indispensable feedstock or fuel.

## ABOUT FUTURE CLEANTECH ARCHITECTS AND OUR HYDROGEN WORK:

Future Cleantech Architects is a climate innovation think tank that exists to close the remaining innovation gaps to reach net-zero emissions by 2050. Our hydrogen works focuses on clean production pathways, addressing challenges along the value chain, and prioritizing its use where it is indispensable as an industrial feedstock or ensures the lowest carbon abatement cost and the most efficient use of clean energy.

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Hydrogen Factsheet

Driving Cleantech Innovation: Future Cleantech Architects (Brochure)

INNOVATION | ENERGY SYSTEMS FLEXIBILITY | CONSTRUCTION | TRANSPORT | HYDROGEN