

CHALLENGES IN HYDROGEN INFRASTRUCTURE AND OFFTAKE

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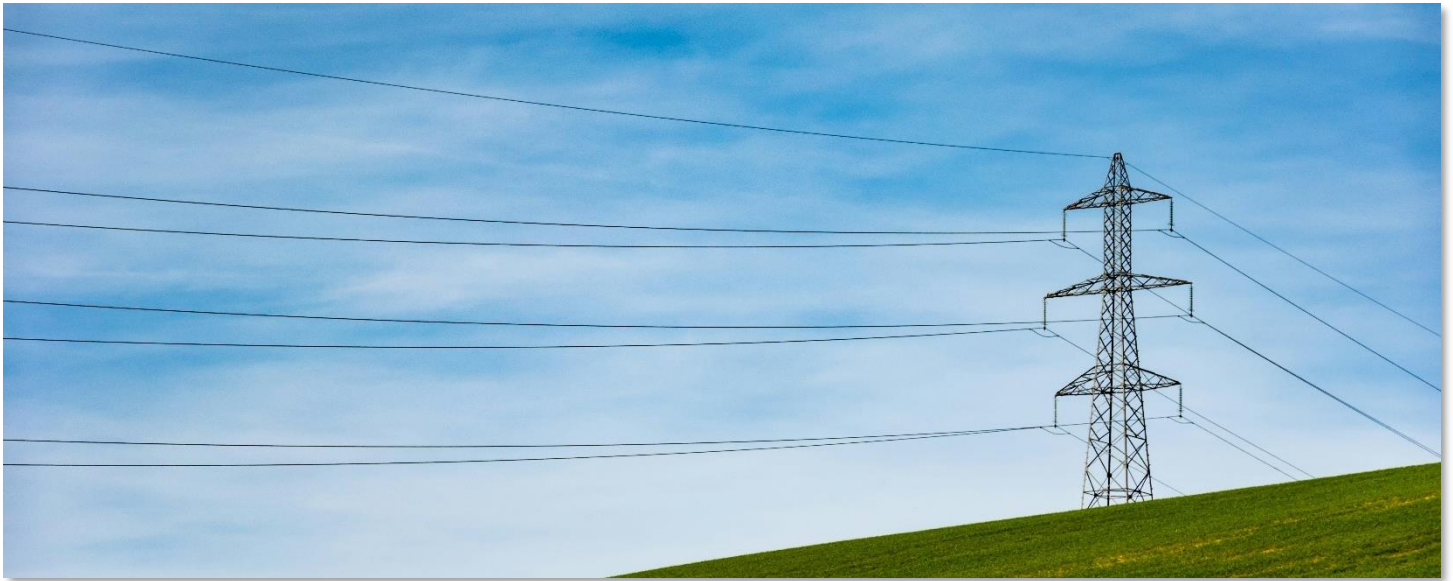


Photo: Thomas Despeyroux via Unsplash

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Context and method

Under Brazil's G20 Presidency in 2024, the Energy Transitions Working Group (ETWG) is a pivotal forum for discussions on the global energy challenges. Co-chaired by Mariana Espécie, Special Advisor to the Minister of Mines and Energy (MME), and Ambassador André Correa do Lago, Secretary for Climate, Energy, and Environment of the Ministry of External Affairs (MRE), the ETWG focuses on (i) accelerating financing for energy transitions, particularly in emerging markets and developing economies, (ii) addressing the social dimensions of this transition, and (iii) exploring innovative perspectives on sustainable fuels.

To enrich discussions on sustainable fuels, Catavento Consultoria conducted an assessment to identify the challenges in developing infrastructure and offtake in the Brazilian green hydrogen market. This involved analyzing the hydrogen market globally and in Brazil, focusing on critical bottlenecks for competitiveness and scaling up, particularly in Brazil. Additionally, Catavento held interviews with 13 external stakeholders, including hydrogen project developers, power sector experts in both generation and transmission, executives from companies in port and pipeline, oil and gas with refinery operations and fertilizer industries. The insights from the research and interviews are consolidated in this concept note.

1. The global hydrogen scenario

Over the past few years, the world has recognized **the relevant role low-carbon hydrogen can play in decarbonizing hard-to-abate sectors that cannot be electrified**, such as steelmaking and shipping. In 2021, the IEA estimated a need for 70 MtH₂/year of green hydrogen capacity by 2030¹ to be on track for net zero by 2050. Europe alone set a target of 20 MtH₂ by the same year².

Since then, there has been a **reality check** and an understanding that while hydrogen will play a very important role, it is not a silver bullet for decarbonizing every sector and must be targeted towards those that lack other options. As of the IEA's latest estimate (July 2023), it now expects green hydrogen production to reach 51 Mt H₂ in a net zero scenario by 2030³, 27% less than the 2021 estimate.

At the same time, **scaling up hydrogen production is challenging**. According to BloombergNEF, while announcements total 62 MtH₂ of green hydrogen production capacity by 2030, projections that consider a more realistic analysis of which projects should come online point to values closer to 16 MtH₂ by 2030. Moreover, approximately 80% of this amount would be concentrated in China, Europe, and the United States⁴.

This revision of expectations was driven by several technical-economic factors, such as:

¹ Financial Times – [“Lex in depth: how the hydrogen hype fizzled out”](#), 2024

² Financial Times – [“Lex in depth: how the hydrogen hype fizzled out”](#), 2024

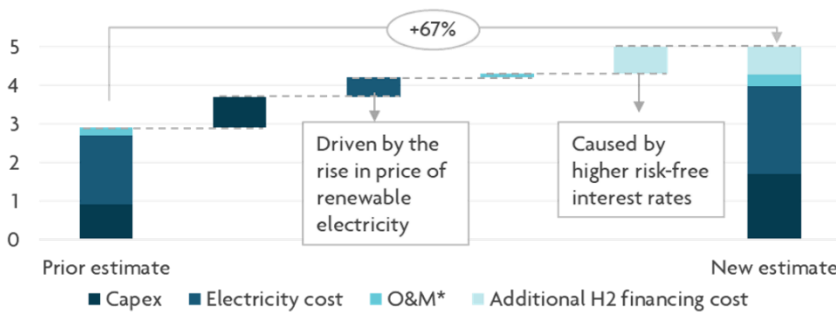
³ Financial Times – [“Lex in depth: how the hydrogen hype fizzled out”](#), 2024

⁴ BNEF – [“IH 2024 Hydrogen Market Outlook: Targets Meet Reality”](#), 2024

- **Challenges in guaranteeing competitive and firm renewable electricity:** Constant and low-cost low-carbon energy is required to meet green hydrogen CO₂ intensity parameters and access subsidies in some geographies. This may demand additional investments in grid infrastructure, which may also incur additional local taxes and tariffs.
- **Increased electrolyzer CAPEX:** Hydrogen production costs rose because CAPEX reduction did not occur as quickly as expected in previous estimates, with alkaline electrolyzers costs potentially being up to 65% higher in 2023 compared to estimates made in 2021 (reaching US\$ 2,200/kW in some regions), although values may differ due to scale and origin.
- **Global macroeconomic scenario:** Increased capital costs due to rising inflation impacted project financing, as CAPEX-intensive business models are being harmed by increased interest rates.

These new perspectives led to **cost estimates up to 67% higher for hydrogen produced on the US Gulf Coast⁵**, for example (Fig. 1).

Fig. 1. Renewable H₂ CAPEX* (US\$/kg)



* US Gulf Coast 1 GW alkaline facility example.

Source: Hydrogen Council – “Hydrogen Insights 2023 – December Update”, 2023

Amid this uncertain scenario, comparatively few projects have reached Final Investment Decision (FID), representing only **5% (2.7 Mt H₂) of the clean H₂ production announced to come online by 2030 (62 Mt H₂)**. The lack of offtake agreements is perceived as a significant barrier for more projects to advance, with only **12% (7.5 Mt H₂) of the planned production capacity for 2030 having any indication of demand or final use**. Of these 7.5 Mt H₂, **just 11% is subject to binding offtake agreements**.

The few projects that have reached FID seem to share a common factor: the **support of public policies**. This highlights the importance of **both supply and demand-side incentives** to scale up this nascent market. These policies include:

- **Direct subsidies**, such as the US Inflation Reduction Act’s 45V tax credits (up to US\$ 3/kgH₂), aiming to reduce projects’ OPEX, as well as credits for equipment production and infrastructure.
- **Double-sided auctions** that aim at matching supply and demand, while covering the green premium via contracts for difference (e.g., EU and German auctions allocated € 1.6 billion in their first tenders).

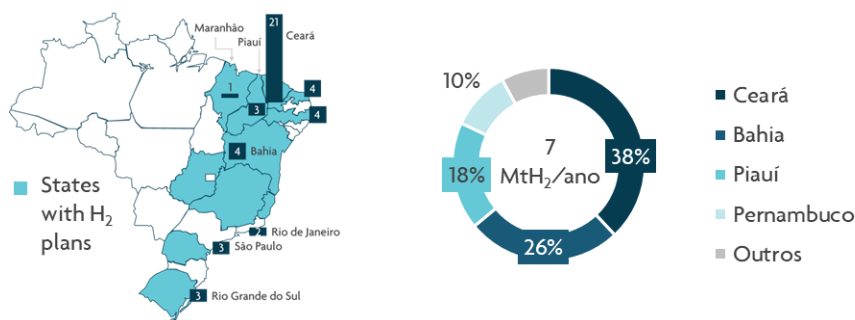
⁵ Hydrogen Council – “Hydrogen Insights 2023 – December Update”, 2023

- **National targets, such as China's goal of producing 200 kt of green H₂ by the end of 2025**, expected to be surpassed by 2024. Additionally, new energy and emissions policies for steel, ammonia, and refining consider H₂ as a key lever.
- **Subsidized funding and fiscal benefits**, as in Saudi Arabia's NEOM project, which received US\$ 2.7 bn in financing from sovereign government funds.

2. The Brazilian hydrogen market

By June 2024, no final investment decision for a hydrogen production project has been made in the country, despite more than 40 preliminary announcements and 12 states already having some kind of plan or strategy for the low-carbon hydrogen economy. These announcements could total **7 Mt H₂ of potential hydrogen production, mainly concentrated in the Brazilian Northeast**, although this number is subject to considerable uncertainty⁶ (Fig. 2).

Fig. 2. Hydrogen project announcements in Brazil



Source: Catavento analysis of news, press releases and MoU announcements for hydrogen production in Brazil since 2021. The majority of projects has not materially evolved since the announcement of MoUs. To convert electrolysis capacity to H₂ production capacity we used 12.4 MW/ktH₂, according to IEA – “[World Energy Outlook](#)”, 2022

Stakeholders involved in hydrogen projects pointed out that legal and regulatory uncertainty, as well as competitiveness challenges, were preventing FIDs and implementation in the Brazilian territory. **The Hydrogen Legal Framework**, approved in Congress and sanctioned by the President in August 2024, creates **Rehidro**, a tax regime for H₂-related equipment, storage, transport, energy production and other CAPEX expenses, exempting those from PIS/PASEP and import tax, although subject to a minimum local content requirement⁷. In parallel, approved through a different Bill in Congress⁸, the **Low Carbon Hydrogen Development Program (PHBC)** allocates R\$ 18.3 bn in tax credits between 2028 and 2032 for H₂ producers and consumers' OPEX-related costs.

These legislative initiatives were signaled as a major driver to overcome initial project barriers, including incentives aimed at making low-carbon hydrogen production more competitive in the short term and facilitating the scaling up of national production.

Beyond the challenges of hydrogen production costs, each project business model will face specific barriers. Investments

⁶ Catavento analysis of news, press releases and MoU announcements for hydrogen production in Brazil since 2021. The majority of projects has not materially evolved since the announcement of MoUs. To convert electrolysis capacity to H₂ production capacity we used 12.4 MW/ktH₂, according to IEA – “[World Energy Outlook](#)”, 2022

⁷ Presidência da República – “[LEI Nº 14.948, DE 2 DE AGOSTO DE 2024](#)”, 2024

⁸ Câmara dos Deputados – “[PL 3027/2024](#)”, 2024

in **transmission infrastructure** are perceived as crucial for all grid-connected green hydrogen projects in Brazil, due to increased energy consumption amid a strained grid.

Export-oriented projects must consider **port infrastructure**, shipping, and conversion costs. Although they may face limitations in accessing Brazilian incentives, which are focused on projects targeting domestic hydrogen consumption, they should be able to obtain green premiums in global markets with robust incentives, such as the European market.

Domestic market-oriented projects face the challenge of securing local **offtake** in a scenario lacking fiscal support or meaningful carbon pricing. Additionally, the **location of hydrogen production** needs to consider the distance to the final consumer and related transportation costs and infrastructure.

3. Infrastructure

i. Power grid

The Brazilian national integrated power transmission system is extensive, reaching **171,000 km of transmission lines⁹**, potentially increasing to **200,000 km by 2028¹⁰**. The system forms a highly renewable electric power grid, achieving **93% renewability in 2023¹¹**, a point considered beneficial for green hydrogen production certification. However, large-energy consuming projects, such as water electrolysis plants, may pressure the grid, requiring CAPEX investments to increase transmission capacity in the specific region where the project will be implemented.

In 2022, EPE estimated that the Brazilian region with the highest grid spare capacity (“entry margin”) was the Northeastern, totaling 99 GW¹². However, upon closer examination of potential subareas for connection to the transmission network, the margin, even in the Northeast region, may be significantly lower, reaching only about **50 MW (~2.5 KtH₂ production)**. For example, Porto de Pecém has announced H₂ production projects that could require 10 GW in renewable generation, while the local grid has only 3 GW of current capacity.

The **cost of these grid upgrades** is subject to intense debates in the power sector. Specialists claim that CAPEX for grid upgrades should be primarily funded by project developers. On the other hand, project developers claim that additional grid fees and other local fees (eg.: CDE) could hamper the competitiveness of hydrogen production in the country, even after considering the low LCOE of solar and wind generation in Brazil¹³.

Additionally, the expansion of the Brazilian transmission system, considering green hydrogen projects, needs to mitigate risks of overinvestment. Although it exists, experts believe that the robust transmission planning process led by the Empresa de Pesquisa Energética (EPE) considerably reduces this risk. In this governance process, large project developers submit their expansion requests to the Ministry of Mines and Energy (MME) for grid connection (Figure 3). Even with the submission of guarantees, it is up to EPE to evaluate whether these projects are credible. Only after conducting a series of

⁹ EPE – “[Estudos para a Expansão da Transmissão: Avaliação Prospectiva das Capacidades Remanescentes de Escoamento do SIN](#)”, 2022

¹⁰ ONS – “[O Sistema em Números](#)”, 2024

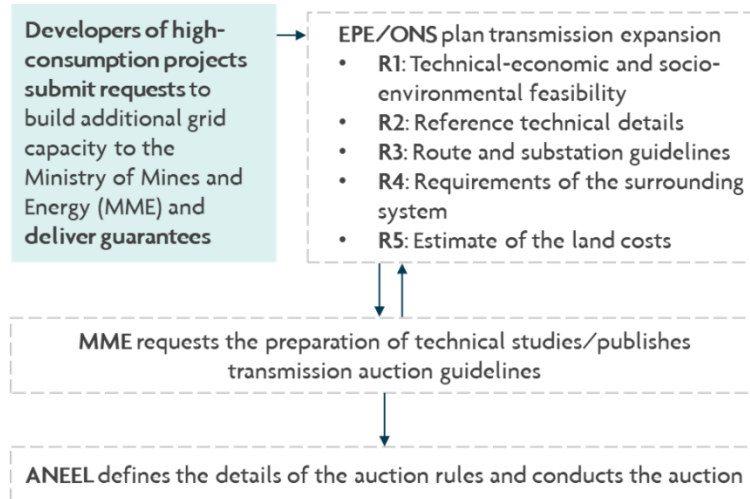
¹¹ EPE – “[BEN Relatório Síntese 2024](#)”

¹² EPE – “[Avaliação Prospectiva das Capacidades Remanescentes de Escoamento do SIN](#)”, 2022

¹³ IRENA – “[Renewable Power Generation Costs in 2022](#)”, 2023

studies (R1 to R5)^{14 15}, does the MME order the power regulatory agency (ANEEL) to conduct transmission line auctions (Fig. 3).

Fig. 3. Governance for transmission grid expansion in Brazil



Source: EPE – “[Planejamento da Transmissão](#)”, 2024; ANEEL – “[Como funciona o leilão de transmissão de energia elétrica?](#)”, 2024

In 2023 and 2024 alone, these auctions mobilized **R\$ 55.6 bn for the construction of approximately 17,000 km of new transmission lines**¹⁶, equivalent to 10% of the existing system, demonstrating the high investment attraction capacity of the current model.

Finally, **storage technologies** could mitigate bottlenecks and reduce the need for significant grid investments. Brazil has a considerable potential for pumped hydro in the South, Southeast, Bahia, and Goiás, among others¹⁷. However, as with large batteries, there are currently no specific public policies that price their ancillary services to the system.

ii. Ports

Port infrastructure is crucial for international market-oriented H₂ production projects. Ports are essential not only for exporting the hydrogen produced but also for importing electrolyzers and other equipment. Additionally, they enable the creation of hydrogen hubs, which leverage synergies and share costs among hydrogen supply chain players and users, particularly in areas related to storage and transportation.

About 4 ports in Brazil already signaled some project or initiative related to low-carbon hydrogen production (Fig. 4) but no facility has started adapting its infrastructure for it.

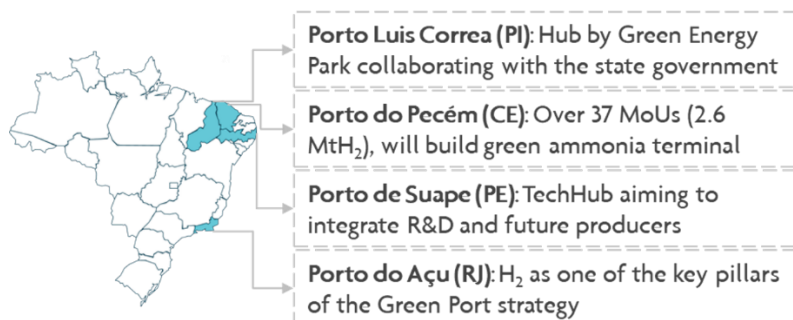
¹⁴ EPE – “[Planejamento da Transmissão](#)”, 2024

¹⁵ ANEEL – “[Como funciona o leilão de transmissão de energia elétrica?](#)”, 2024

¹⁶ EPE – “[Leilão de Transmissão nº 001/2024](#)”, 2024

¹⁷ GESEL – “[A Viabilidade das Usinas Reversíveis no Sistema Interligado Nacional](#)”, 2021

Fig. 4. Highlights from Brazilian ports on hydrogen



Source: Catavento analysis based on Investe Piauí – “[Hubs de Hidrogênio Verde](#)”, 2024; Flanders Investment & Trade – “[Hydrogen in Brazil](#)”, 2023; Governo do Estado do Ceará – “[Em Roterdã, governador do Ceará assina memorando com Eletrobras para produção de hidrogênio verde no Complexo do Pecém](#)”, 2024; EPBR – “[Pecém seleciona operadora para terminal de exportação de amônia verde](#)”, 2024)

Key criteria and adaptations must be considered when thinking about a port that can be used as a hydrogen hub^{18 19 20}:

- **Land availability** – hydrogen production, storage, transportation, and usage may face challenges in densely built or urban areas.
- **Water resources** – regions with local water stress should be avoided, while risks can be mitigated with high-cost desalination plants.
- **Renewable and firm electricity** – competitive energy and access to grid connection (or costs for expansion) are crucial to reduce the levelized cost of hydrogen (LCOH).
- **Transportation logistics** – coordination among players is needed for standardization of storage equipment, pressure, and temperature.
- **Safety standards** – alignment with global best practices must guarantee safety levels comparable to handling fossil molecules. This is particularly relevant for green H₂-based ammonia exports, that need to adapt tank terminals to deal with larger volumes and lower temperatures, while managing societal perception over its toxicity risks.

iii. Pipelines

The **use of natural gas pipelines** has been globally assessed for transporting hydrogen over long distances, emphasizing the need for adjustments in their specifications to prevent leaks and equipment degradation, as well as to preserve the product's integrity²¹. However, experts indicate that there is a technical limitation on the possible hydrogen blend in these existing natural gas pipelines and that injecting hydrogen into these networks might not make technical or economic sense²².

¹⁸ Clean Hydrogen Partnership – “[Report 1: Study on hydrogen in ports and industrial coastal areas](#)”, 2023

¹⁹ Clean Hydrogen Partnership – “[Report 3: Study on hydrogen in ports and industrial coastal areas](#)”, 2023

²⁰ Notteboom e Haralambides – “[Seaports as green hydrogen hubs: advances, opportunities and challenges in Europe](#)”, 2023

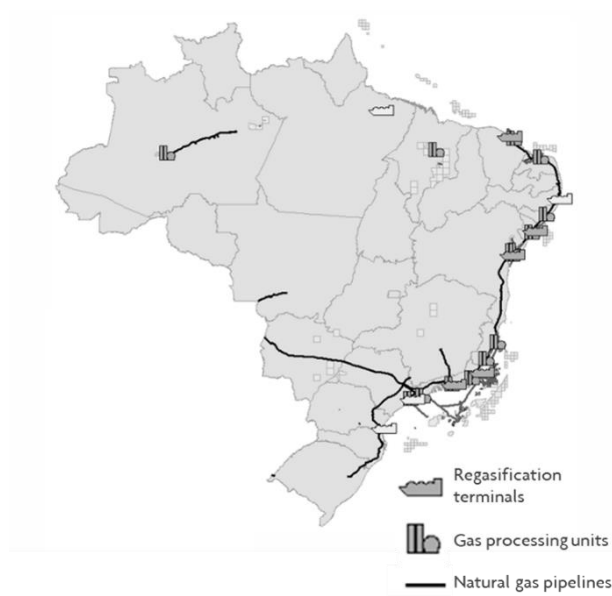
²¹ H2 Brasil – “[Coleção 1. Conceitos do H2 Power-To-X - Volume 4. Aspectos sobre o armazenamento e transporte de hidrogênio](#)”, 2023

²² Interviews

Specifically analyzing the Brazilian case, Brazil is currently home to 9,400 km of transportation pipelines²³ (Fig. 5). Comparing with countries like Germany, which has plans to adapt its natural gas transport network to use hydrogen, we find that the Brazilian network is **35 times smaller than Germany's**²⁴, despite the country having an area **24 times larger**.

Given this situation, if hydrogen pipelines are needed in Brazil, experts believe that greenfield projects would make more

Fig. 5. Brazilian natural gas infrastructure



Source: EPE – “[Apresentação do PIPE 2023](#)”, 2024

economic and technical sense than adapting the limited natural gas network. Furthermore, as announcements are favoring project installations in port regions or near consuming industries, a national network might not be necessary. Instead, transportation to each plant through **short, dedicated pipelines** – with costs potentially shared among different players – could be more practical. In this context, experts do not view pipelines as a bottleneck for the development of the Brazilian green hydrogen economy.

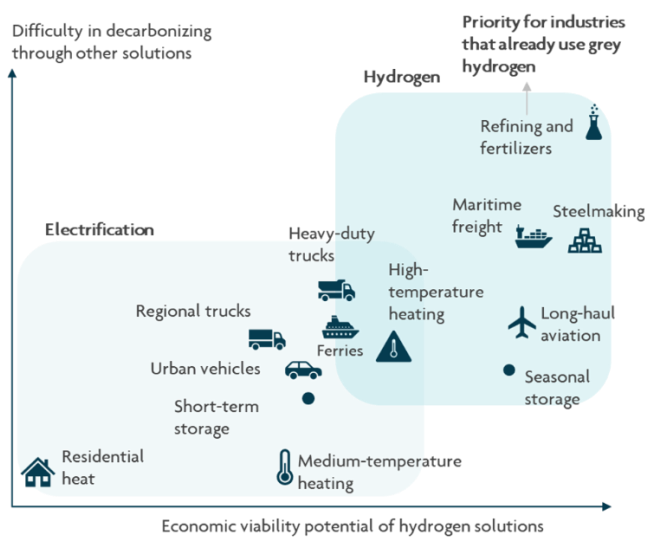
²³ EPE – “[Apresentação do PIPE 2023](#)”, 2024

²⁴ Gasunie – “[Status Quo](#)”, 2024

4. Demand

Greater clarity on the barriers to creating a hydrogen economy requires not only a focus on project viability but also on what is preventing greater offtake signals by potential hydrogen users. The demand for hydrogen should be concentrated in sectors that already use fossil-based hydrogen (e.g.: refineries and nitrogen fertilizer production) or industries where other decarbonization alternatives are less viable (e.g.: steelmaking)^{25 26} (Fig. 6).

Fig. 6. Hydrogen attractiveness for each application



Source: Catavento analysis based on IRENA – “[Geopolitics of the Energy Transformation: The Hydrogen Factor](#)”, 2022; Liebreich Associates – “[Hydrogen Ladder Version 5.0](#)”, 2023

i. Refining

Hydrogen is already used in refineries for sulfur removal or hydrotreatment processes and is typically produced onsite through fossil natural gas reforming (grey hydrogen). Hydrogen consumption in refineries is projected to increase in the medium term, given that a larger share of refineries' portfolios is being directed toward renewable diesel (HVO) and sustainable aviation fuel (SAF) production.

The sector is seen as a key area for scaling up low-carbon hydrogen, as switching to the green version of the input would require **little to no additional investments** in equipment or process change, apart from addressing the potential **increased production costs** and willingness of final clients to pay a **green premium**. Globally, oil and gas companies have recently shown positive signs for hydrogen in decarbonizing refineries:

- **TotalEnergies** signed a 15-year offtake agreement with Air Products for 70 kt/year of green H₂ from 2030, coming from Saudi Arabia. The company intends to use the product in its European refineries, focusing on the production of low-carbon fuels and leveraging European mandates²⁷.

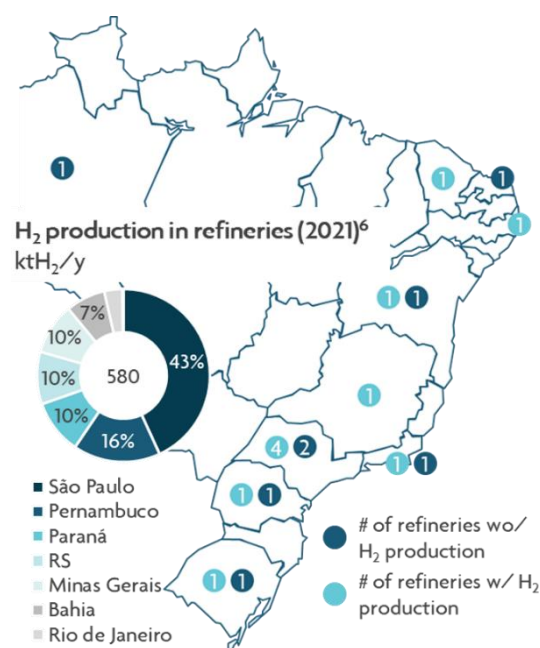
²⁵ IRENA – “[Geopolitics of the Energy Transformation: The Hydrogen Factor](#)”, 2022

²⁶ Liebreich Associates – “[Hydrogen Ladder Version 5.0](#)”, 2023.

²⁷ Air Products – “[Decarbonization of European Refineries: A first agreement signed between TotalEnergies and Air Products for the delivery of Green Hydrogen](#)”, 2024

- In 2022, **Shell** made FID for a 200 MW green H₂ plant at its refinery in the Port of Rotterdam. The company decided to meet its own demand due to difficulty finding long-term customers²⁸. The same decision was also made recently in taking FID on Refhyne 2, a 100 MW green hydrogen project that will supply its refinery in Germany²⁹.

Fig. 7. Brazilian refineries and hydrogen production capacity (2024)



In the Brazilian case, **11 out of 19 refineries** in the country have hydrogen production capacity that total 580 ktH₂/year, with only **55% of this capacity used in 2021^{30 31}** (Fig. 7). **95% of this production capacity currently belongs to Petrobras³²**, highlighting how the company's positioning is crucial to kick of green hydrogen use in Brazilian refineries. The company is evaluating possible business models for the use of low-carbon hydrogen, having recently signaled the possibility of incorporating the input into its planning. However, specificities of each Brazilian region will also be taken into account, with alternatives such as biomethane also being evaluated for refineries in the Southeast of the country³³.

Source: EPE – “*Produção e Consumo de Hidrogênio em Refinarias no Brasil*”, 2022;
 ANP – “*Painel Dinâmico Produtores de Derivados Fósseis*”, 2024

ii. Fertilizers

Despite its booming agricultural production, **Brazil is a major importer of fertilizers, with 95% of its demand for nitrogen fertilizers**, which require hydrogen for production, being met by imports³⁴.

Brazil currently has **three plants producing nitrogen fertilizers** (two operated by Unigel and one by Yara) that are capable of producing urea, ammonium sulfate, and ammonium nitrate³⁵. However, production at these plants is below capacity due to issues such as the high cost of natural gas and significant losses, which led Unigel to undergo a corporate restructuring process due to severe financial distress. Additionally, 70% of the nitrogen fertilizers imported by the country are urea³⁶, which contains carbon and is therefore less frequently viewed as a viable option for agriculture decarbonization.

²⁸ Hydrogen Insight – “*ANALYSIS | With FIDs taken on three major green hydrogen projects last week, is the European sector finally taking off?*”, 2024

²⁹ Shell – “*Hydrogen*”, 2024

³⁰ EPE – “*Produção e Consumo de Hidrogênio em Refinarias no Brasil*”, 2022

³¹ ANP – “*Painel Dinâmico Produtores de Derivados Fósseis*”, 2024

³² GIZ – “*Mapeamento do Setor de Hidrogênio Brasileiro*”, 2021

³³ Interviews

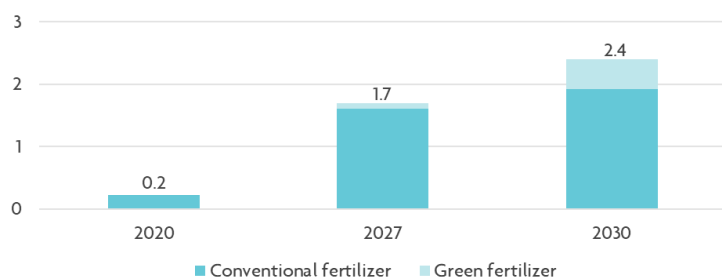
³⁴ GlobalFert – “*Outlook GlobalFert 2024*”, 2024

³⁵ GlobalFert – “*Outlook GlobalFert 2024*”, 2024

³⁶ GlobalFert – “*Outlook GlobalFert 2024*”, 2024

The **National Fertilizer Plan** (PNF, in Portuguese), approved in 2023, outlines green ambitions without restricting production routes. Among the goals set is for **5% of national nitrogen fertilizer production to be green by 2027 and 20% by 2030**³⁷ (Fig. 8). The plan could potentially drive demand for up to **100 kt of green hydrogen by 2030**, equivalent to 1 GW of electrolyzer capacity and 2.1 GW of renewable generation³⁸.

Fig. 8. National production of nitrogenous fertilizers in the PNF (Mt N)



Source: MDIC – “[Plano Nacional de Fertilizantes 2050](#)”, 2023

Atlas Agro is currently the only company that has announced plans for green fertilizer production from hydrogen in Brazil, aiming for 170 kt N³⁹.

The Brazilian green fertilizer sector still faces considerable **challenges** in reaching these targets. The national plan does not provide clear **incentives for scaling up demand**, such as mandates. Although Brazil is a major consumer and importer of fertilizers, the economic viability of low-carbon products is hampered by a **lack of competitiveness**. Fertilizer prices are typically not based on long-term contracts, and consumers, such as commodity producers, cannot pass the **green premium** onto their final products. As a result, they are unlikely to pay a higher price for low-carbon fertilizers.

iii. Steelmaking

Hydrogen is considered a relevant pillar for decarbonizing steel production, accounting **for 21% of emission reductions in the sector by 2050 in the IEA's net zero emissions scenario**⁴⁰.

Most hydrogen-based steelmaking projects rely on the **electric arc furnace (EAF) route**, which represents 29% of global steelmaking capacity⁴¹ and primarily uses steel scrap and other ferrous products as inputs (e.g., Direct Reduced Iron – DRI). Pure EAF and DRI-EAF projects account for 95% of announced low-carbon steel production capacity by 2030, totaling approximately 100 million tons⁴². However, this value still represents only a small fraction of the global annual steel production, which stands at 1.9 billion tons of crude steel as of 2023⁴³.

³⁷ MDIC – “[Plano Nacional de Fertilizantes 2050](#)”, 2023

³⁸ Ammonia = 82% N; 1 ton of ammonia requires 178 kg of hydrogen; 1 Mt of green hydrogen requires about 10 GW of electrolyzers and 20 GW of renewable power capacity

³⁹ Atlas Agro – “[Uberaba Green Fertilizer](#)”, 2024

⁴⁰ IEA – “[Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach - 2023 Update](#)”, 2024

⁴¹ Worldsteel – “[World Steel in Figures 2024](#)”, 2024

⁴² BNEF – “[Industry Decarbonization Market Outlook 1H 2024](#)”, 2024

⁴³ Worldsteel – “[World Steel in Figures 2024](#)”, 2024

Globally, the **key factors for enabling FIDs for green hydrogen-based steel projects** are seen as:

- Offtake agreements that accept a green premium, such as H2 Green Steel deals with the automotive industry^{44 45};
- Competitive funding, leveraging debt, equity, and government incentives;
- Access to low-cost clean power, as well as grid and transportation infrastructure.

In **Brazil**, steelmaking is concentrated in the Southeast of the country, with 23% of national production using the EAF route. Although 11% of national production currently uses **charcoal** as an input, there is little prospect for deep decarbonization efforts in the short term, such as converting Blast Furnace–Basic Oxygen Furnace (BF-BOF) equipment to EAFs. Therefore, green iron production is seen as an **export and neo-industrialization business opportunity** in the country.

Brazil offers several advantages for producing high-quality and competitive iron-based products for the international market. According to Agora Energiewende, DRI produced in Brazil could be up to 16% cheaper than European DRI due to lower-cost renewable electricity generation⁴⁶. Additionally, Brazil stands out due to its high-concentration iron ore: Vale, the Brazilian mining company, supplies 37% of the global iron ore with a grade above 66%⁴⁷. While global iron ore reserves average a grade of 46%⁴⁸, Brazilian reserves are in the range of 55%, reaching up to 65% in Pará⁴⁹.

5. Final remarks

Expectations and timelines are currently under review both globally and in Brazil. Not all announced initiatives will come to fruition, and those that do are likely to experience delays due to the influence of public policy. Thus, the hydrogen economy remains a competitive landscape.

In infrastructure, there will indeed be a transmission bottleneck requiring investments, but with proper planning, gradual deployment and with realistic cost allocation, the risk of overinvestment is reduced. Ports require adaptations but are not considered the main bottlenecks for the Brazilian hydrogen market.

Cost is the main challenge for demand commitment. Prices have been revised across all cost components (e.g.: electrolyzer, energy). Projects moving forward have strong government support to close the green premium gap. It is unclear whether the appetite for the premium will grow.

Potential game changers in the industry include cost factors, notably China's electrolyzer prices and the overall macroeconomic environment. In Brazil, the **incentives** under the new legal framework, as well as the **alignment to international certification standards** will be pivotal in fostering the market. **Despite challenges, Brazil remains a significant contender and has not yet missed its window of opportunity.**

⁴⁴ H2 Green Steel – “[Mercedes-Benz and H2 Green Steel announce agreements in both Europe and North America](#)”, 2023

⁴⁵ H2 Green Steel – “[Porsche plans to use CO2-reduced steel from H2 Green Steel in sports cars from 2026](#)”, 2023

⁴⁶ Agora Energiewende – “[12 Insights on Hydrogen – Brazil Edition](#)”, 2024

⁴⁷ Vale – “[Webinar de Soluções para siderurgia](#)”, 2023

⁴⁸ USGS – “[Mineral Commodities Summary 2024](#)”, 2024

⁴⁹ ANM – “[Anuário Mineral Brasileiro 2022](#)”, 2023

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