



Challenges in hydrogen infrastructure and offtake

Executive summary

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Project context and objective



Strategic vision in hydrogen

Context

- Alignment with the thematic priorities of the Energy Transitions Working Group G20 in 2024, in which Catavento supported throughout the year with high-level roundtables and strategic content

Goal

- Identification of challenges in the development of infrastructure and demand (offtake) in the Brazilian green hydrogen market

Method

- Analysis of the H₂ market globally and in Brazil, focusing on critical bottlenecks for competitiveness and scaling up, particularly in Brazil
- Conduction of interviews with 13 external stakeholders from the infrastructure (e.g.: ports, pipeline operators) and potential offtakers (e.g.: refineries, fertilizer producers, iron & steel)

Desk research to map the main infrastructure and demand challenges



The global hydrogen scenario

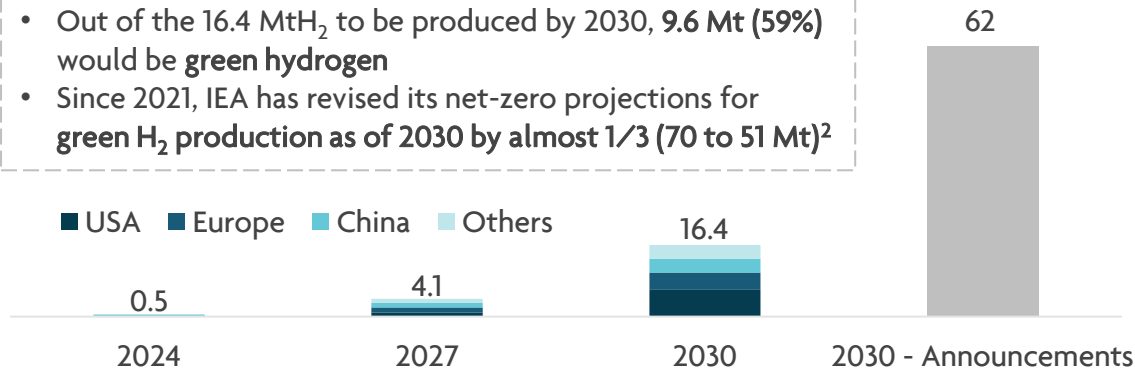
Revisited expectations amid challenges in supply and demand



Increase in hydrogen supply is proving to be challenging

Low-carbon hydrogen production estimates, Mt/year¹

- Out of the 16.4 MtH₂ to be produced by 2030, **9.6 Mt (59%)** would be **green hydrogen**
- Since 2021, IEA has revised its net-zero projections for green H₂ production as of 2030 by almost 1/3 (70 to 51 Mt)²



Challenges in upscaling hydrogen supply²

Firm renewable energy, considering investments in grids infrastructure, local taxes and tariffs (+ US\$ 0.5/kgH₂)

Electrolyzers, primary drivers of higher CAPEX (up to +65%⁵), although values may differ due to scale and origin*

Financing, given CAPEX-intensive business models that are being harmed by increased interest rates (+ US\$ 0.7/kgH₂)

A limited number of projects have guaranteed offtake contracts⁴

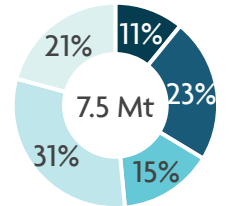
H₂ offtake by agreement type (2030), Mt



Clean H₂ offtake remains at **12% (7.5 Mt)** of the **2030 announced production capacity (62 Mt)**. This scenario is resulting on less announcements and more focus on incentivizing demand



As of May 2024, out of all clean H₂ production announced to come online by 2030 (62 Mt), **only 5% (2.7 Mt) has reached FID**



- Binding offtake
- Self consumption
- Pre-contract
- MoU

Diverse public policies are being used to foment the H₂ economy



Direct subsidies, such as the IRA's 45V tax credits (OPEX) and credits for equipment production (CAPEX) in the US⁵



Double-sided auctions, a mechanism utilized by the EU and Germany^{6,7} (OPEX)



National targets, such as the Chinese goal of 200 kt of green H₂ by 2025⁸



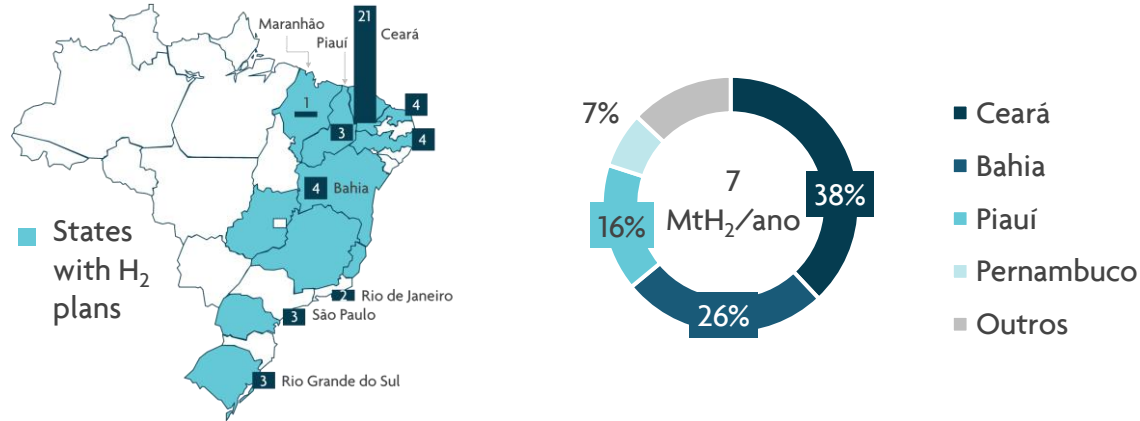
Subsidized funding, as in NEOM (Saudi Arabia), receiving financing from sovereign funds (CAPEX)^{9,10}

The Brazilian hydrogen market

Uncertain regulatory framework and lack of incentives were preventing FIDs



Since late 2023, no FID was taken in announced H₂ projects in Brazil...¹



...mainly due to expected sign-off of incentives in the Hydrogen Bill²

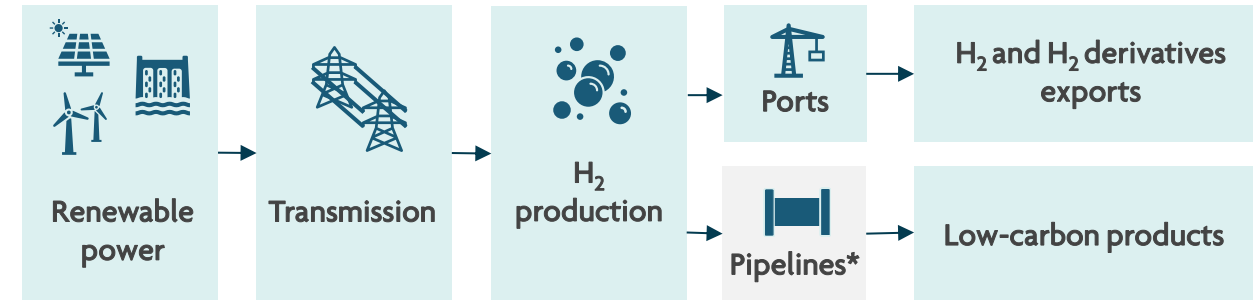


Approved in Congress and sanctioned by the President, it creates **Rehido**, a tax regime (w/ a minimum local content requirement) for H₂-related equipment, storage, transport, energy production and other CAPEX expenses, exempting those from PIS/PASEP and import tax

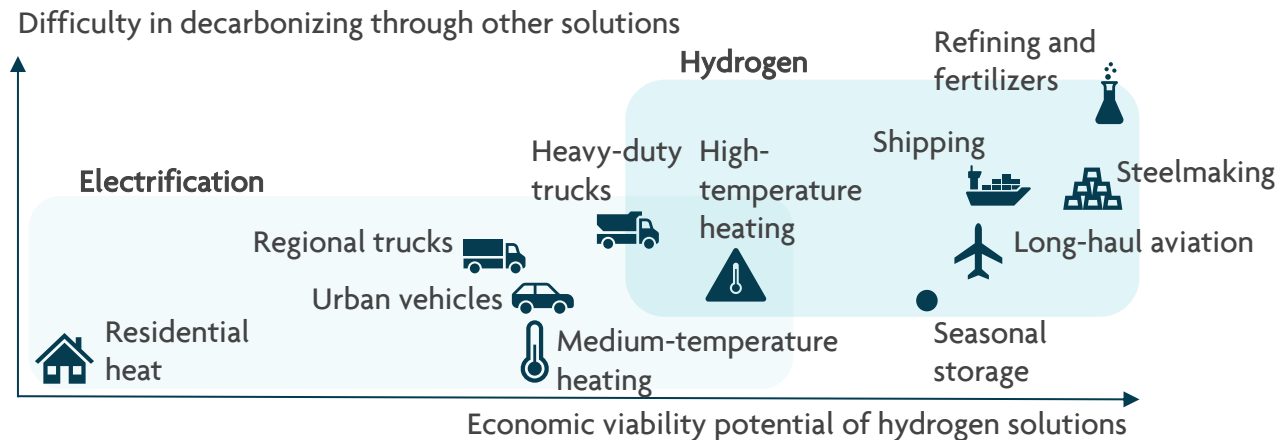


Approved through a different Bill in the Lower House, the **Low Carbon Hydrogen Development Program (PHBC)** allocates R\$ 18.3 bn in tax credits between 2028 and 2032 for H₂ producers and consumers' OPEX-related costs³

Each H₂ project business model will face specific infrastructure challenges



Hydrogen attractiveness for each application^{4 5}



Infrastructure

Investment requirements are made clearer as H₂ plans become more detailed



Power transmission

- The highly-renewable SIN (93%)¹ is **extensive**, but large energy-consuming projects may require grid investments, since excess capacity may be as low as 50 MW in some regions³
- The impact of data centers and H₂ projects on grid expansion planning is being evaluated by EPE to **prevent overinvestment in grids**
- The **greater use of storage technologies** to mitigate grid investment requirements depends on specific policies that **adequately price their ancillary services**⁴



Ports

- Ports can also become **hydrogen export hubs**, leveraging synergies for sharing costs from H₂ infrastructure, such as **storage**, and **H₂-based fuels tanking**⁵
- **About 4 ports** in Brazil (CE, PI, PE, RJ) already signaled some project or initiative related to low-carbon hydrogen production, but **no facility has started adapting its infrastructure for it**^{6 7 8}
- **Ports' land and water availability**, as well as access to the power grid and competitive energy are critical for economically-viable and scalable plants^{5 9 10}



Pipelines

- The use of natural gas pipelines would require **changes in some of its specifications to prevent leaks and embrittlement** due to the distinct properties of hydrogen
- **Brazil's natural gas infrastructure is comparably small**¹¹ (35x smaller than Germany's¹²), thus requiring more effort in greenfield development than adaptation
- H₂ production in Brazil is being evaluated close to industries and ports, **mitigating the need for large pipelines**. Short, dedicated ones could potentially be shared among different players in the same H₂ hub

Demand

Reality check in hydrogen perspectives increases focus for specific sectors



Refining - 43% of existing demand (41 Mt H₂)

- The offtake in the sector is **starting to advance mainly in Europe**, with Shell taking FID on 300 MW of electrolysis for its refineries^{1,2} and TotalEnergies signing a 15-year deal to ship H₂ from Saudi Arabia³
- Hydrogen in Brazilian refineries is **directly dependent on Petrobras' strategy**, which is responsible for 95% of the national production for this purpose⁴
- The choice between a business model of self-production and a firm outsourced supply is to be considered on a case-by-case basis



Fertilizers - 33% of existing demand (32 Mt H₂)

- Despite having domestic production capacity, **Brazil imports 95% of its nitrogen fertilizer demand⁵** due to the alleged high costs of natural gas
- The PNF* sets ambitious targets for national production: achieving **5% green production by 2027 and 20% by 2030⁶**, which would require ~100 ktH₂ (~2.1 GW). However, no incentives are disclosed
- Currently, only one player (Atlas Agro)⁷ has plans for production from green H₂, with **lack of customer willingness to pay a premium being a key barrier**



Steelmaking - 6% of existing demand (5 Mt H₂)

- H₂ is considered one of the critical pillars for decarbonizing steel production, representing **21% of the sector's emissions reduction in the IEA NZE by 2050⁸**
- The **EAF route** is becoming the basis of the steelmaking transition, with 94% of announced low-carbon capacity being based on this route (BNEF)⁹
- In Brazil, **H₂-based DRI** is considered a business opportunity, export and neo-industrialization agenda

Hydrogen infrastructure and demand

Final remarks



Emerging barriers may delay, but not dismiss efforts to establish a hydrogen ecosystem



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 the main bottlenecks



Cost is the main challenge for demand commitment. Prices have been revised across all cost components (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 approval of **incentives under the new legal framework**, as well as **alignment to international certification standards** are pivotal in fostering the market. Despite challenges, **Brazil remains a significant contender and has not yet missed its window of opportunity**

Hydrogen infrastructure and demand

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