



***Brazil:** powerhouse for accelerating **Europe's** energy transition*



Foreword

The European Union has set ambitious energy transition targets to mitigate climate change, such as making 100 European cities carbon neutral by 2050. In this scenario, cooperation with international partners will play an increasingly strategic role in order to meet the European market's growing demand for clean energy.

Since Brazil has one of the cleanest electricity matrices in the world, the country can be one of Europe's biggest partners in the expansion of sustainable business and energy transformation. With continental dimensions, the country has enormous wind and solar potential, added to an integrated, low-carbon electricity system that allows European companies and investors to develop new renewable energy generation projects.

With such attributes in renewables abundance, Brazil can become one of the global leaders in the production of green hydrogen. The country has an advantageous geographic position to reach Europe, as well as a strong domestic industry, which allows production both for the domestic market and for export and meet the demands of the European market.

Green hydrogen will contribute to the decarbonization of the global energy matrix as a fuel or feedstock and will create an investment opportunity of USD 200 billion in Brazil over 20 years, according to a report by the consulting firm McKinsey.

In this edition of #PdAInsights, we bring relevant information about the Brazilian potential for renewable generation and green hydrogen production, which open new business possibilities for the European market. The decarbonization of value chains will require global efforts, and the data presented here lead us to an additional conclusion: Brazil has a key role to support and provide the energy transformation of Europe.

In this context, the Port of Açu has a unique opportunity to enable new energy businesses, being the gateway to low-carbon initiatives in the country. The green hydrogen, wind and solar generation projects, in or near the Port of Açu, are part of a set of initiatives that will help place Brazil in a prominent position in global efforts to transition to a low-carbon economy. The challenge has already begun: the energy revolution in Brazil starts here.



Mauro Andrade

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#1

Growing demand *for clean energy in Europe*

The European Union's energy matrix relies heavily on fossil fuels with high dependence on imports from countries like Russia. In 2020, only 17% of the bloc's matrix was renewable.

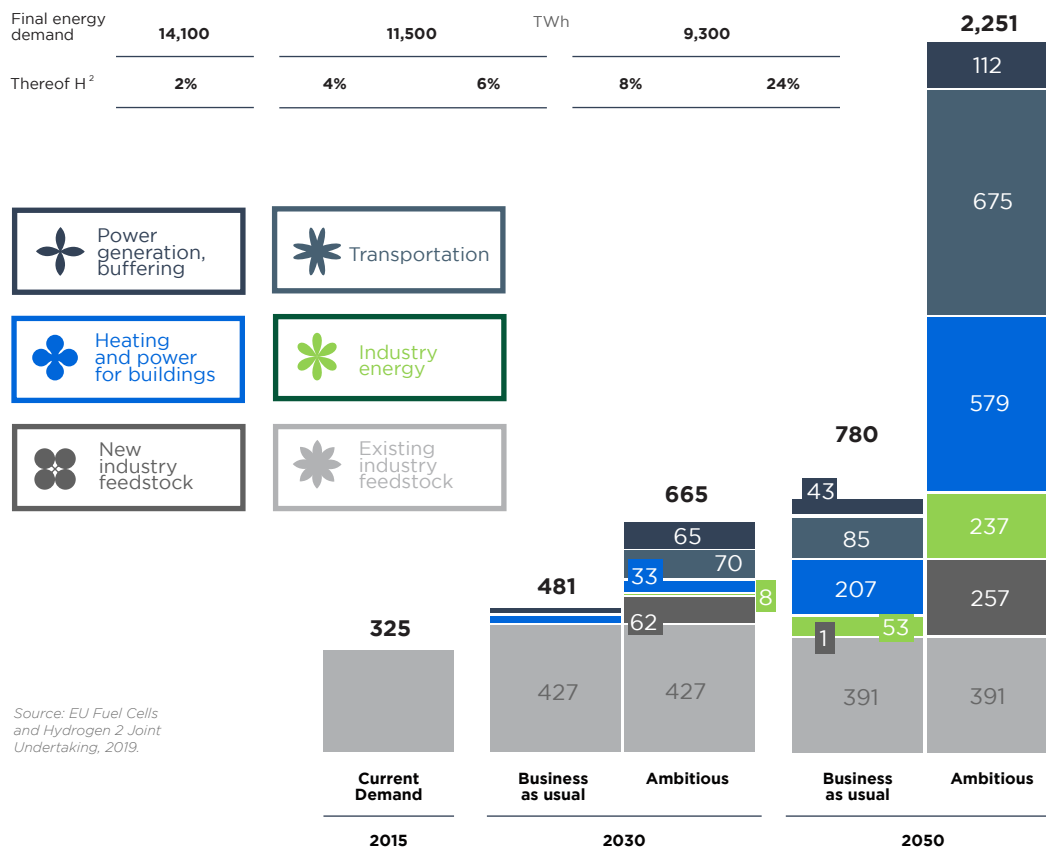
With the Green Deal, Europe set bold goals, among them:

- Reduce its net greenhouse gas emissions by at least 55% by 2030;
- Achieve climate neutrality by 2050.

This means not only expanding current solar, wind and biofuel power generation capacity massively, but also increasing the use of hydrogen (H₂) as an energy source.

H₂ could reach up to ¼ of the European Union's energy demand, with an emphasis on green hydrogen.

HYDROGEN COULD SUPPLY UP TO **24%** OF TOTAL ENERGY DEMAND IN THE EUROPEAN UNION BY 2050



Green H₂ is considered the **“fuel of the future,”** obtained from the electrolysis of water with renewable energy and then used as an energy source or feedstock. Because it can be stored and transported in the molecular form, it is a way of storing renewable energy, allowing countries with renewable demand, such as Germany, to import Green H₂ to meet their needs.

Europe’s goal is to achieve 40 GW in hydrogen electrolysis by 2030 and a further 40 GW in non-EU countries for export to Europe. **For the development of these projects, USD 70 billion of public funding has already been announced.**



#2

Brazil: *renewable
powerhouse*

175 GW

Brazilian renewable
generation in 2021

3rd

country in the world
in renewable power
generation in 2020

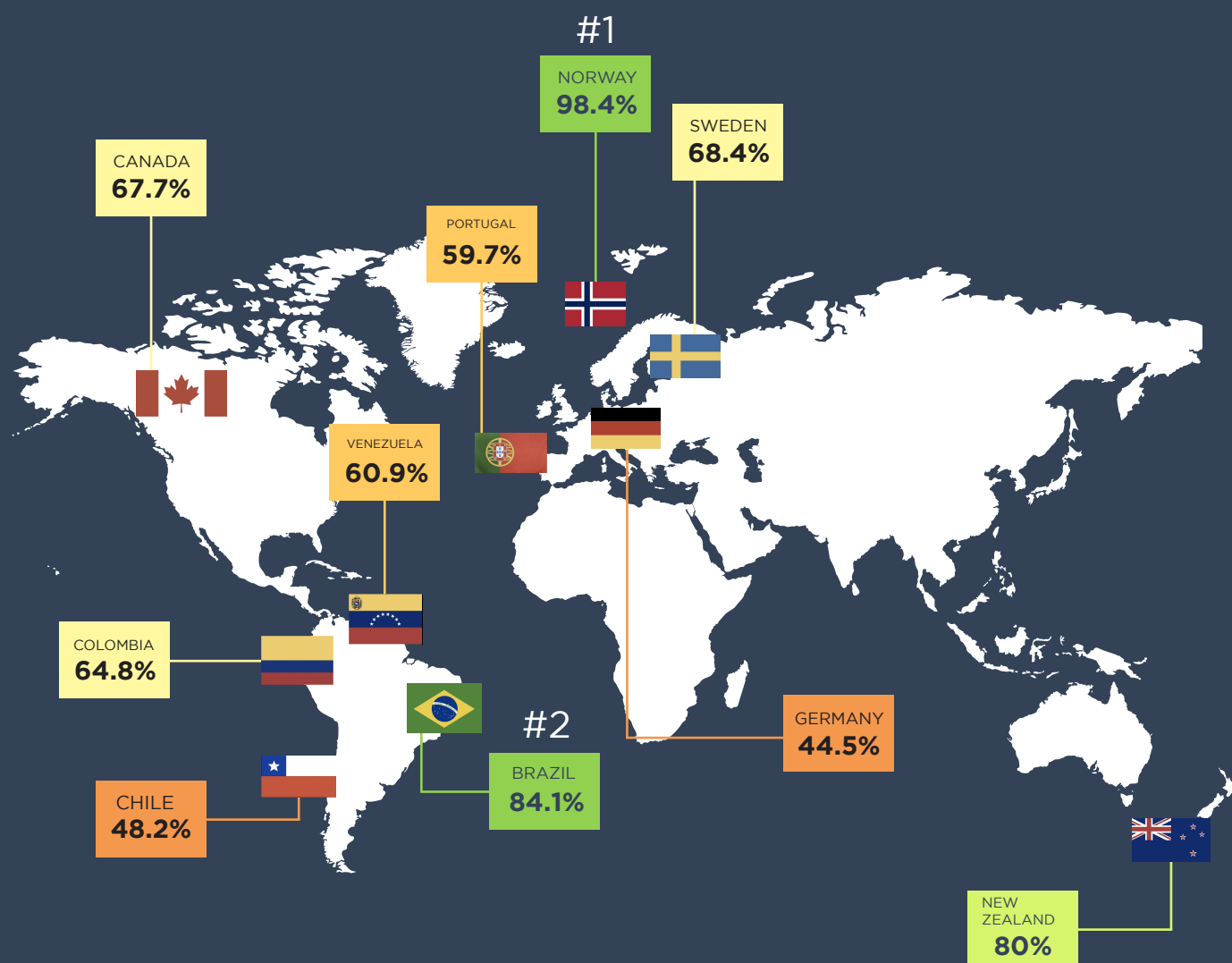
84%

renewable electricity
matrix in 2020 making
Brazil the 2nd in the world

47%

forecasted share of wind
and solar power in 2040,
including offshore wind
potential

COUNTRIES WITH THE GREATEST PARTICIPATION OF RENEWABLES IN ELECTRICITY GENERATION



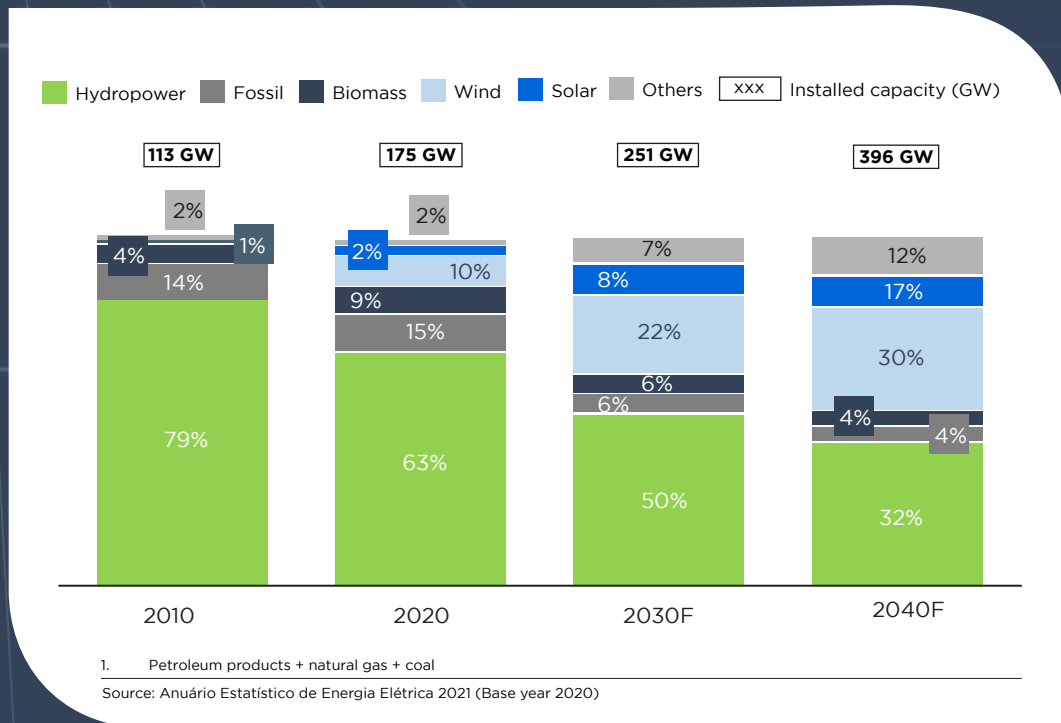
1º Norway
2º Brazil
3º New Zealand
4º Sweden
5º Canada

6º Colombia
7º Venezuela
8º Portugal
9º Chile
10º Germany

Source: Global Energy Statistical Yearbook (Enerdata).



BRAZIL HAS CLEAN ENERGY GENERATION INFRASTRUCTURE WITH ONLY 15% OF INSTALLED CAPACITY FROM FOSSIL SOURCES



Highlights



Hydroelectric generation less and less predominant over the years;



The percentage of **thermoelectric** generation is reduced but still necessary to guarantee the security of the system;



Biomass remains stable as an energy source;



Wind energy is a consolidated source of electricity that tends to grow;



Solar energy has grown extensively in Brazil recently (CAGR 2012-20 of 132%) and tends to grow even more;

#3

*Wind and solar in Brazil: potential to reach **186 GW** by 2040*

The fastest growing participation in the Brazilian total installed capacity is from wind and solar photovoltaic resources, which represent respectively 11% and 2% of the capacity in 2021, but should reach 30% and 17% by 2040.

Brazil is blessed with good winds: while the world average capacity factor was 36% (in 2020), **the average for Brazil registered 41% in that same year, reaching 59% during the “Windy Harvest” period***. The Brazilian capacity of installed onshore wind power generation is already 21.6 GW, and it is the 3rd largest producer in the world. There are also another 12.7 GW of capacity already contracted, which represents a guaranteed increase of almost 60% over current capacity. Higher capacity factors are expected for offshore wind in Brazil.

THE GOOD WINDS OF BRAZIL

41%

was the average Capacity Factor in Brazil in 2020

59%

was the highest average monthly Capacity Factor that wind energy in Brazil achieved during the 2020 wind harvest period

36%

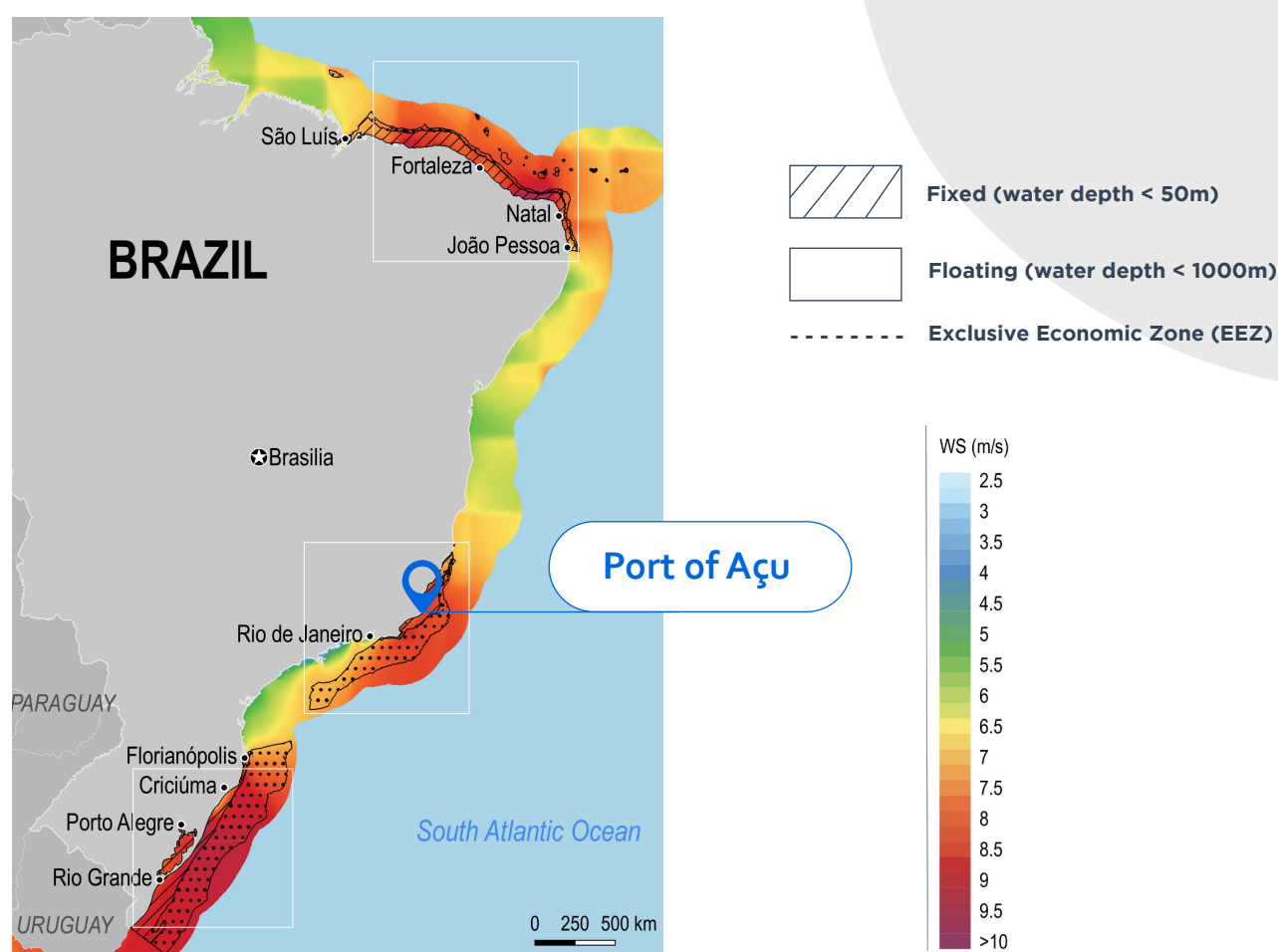
is the approximate average Worldwide Capability Factor

Although wind generation is currently onshore, the Brazilian coast has three wide platforms with potential for offshore exploration, i.e., up to 50m deep and with an average wind speed higher than 8m/s: **the Northeast coast, the East coast of Rio de Janeiro, and the South coast.**

BRAZIL'S COASTLINE HAS THREE REGIONS WITH POTENTIAL FOR NEW OFFSHORE WIND PROJECTS

RISE score: 71

Fixed: 480 GW // Floating: 748 GW // Total: 1,228 GW



Source: World Bank, 2020.

These regions already add up to more than 160 GW in wind projects being licensed. In eastern Rio de Janeiro alone, in the Campos Basin, **there are already 33 GW being licensed by major international players such as Shell, Equinor, and Totalenergies and Neoenergia (controlled by Iberdrola).**

Regarding solar generation, **the country jumped from 1.1 GW of installed capacity in December 2017 to 15.3 GW in April 2022, 13 times more in less than 5 years.***

Brazil was the 5th country in solar capacity expansion in 2021 and expects an annual growth of 39% by 2026, reaching more than 54 GW of generation in the next 4 years.**

Both wind and solar generation growths are driven in large part by the lower cost of these sources. The **Levelized Cost of Energy (LCOE)** of onshore wind energy is currently in the range of USD*** 22 to 27 per MWh in the northeast region of Brazil, with an expected reduction of 27% by 2040; Solar energy currently costs between USD 27 to 34 per MWh in the southeast region and between USD 24 to 32 in the northeast region, **but its average LCOE will decrease by 46% by 2040.**

Onshore Wind
LCOE could reduce

27%

from 2020 to 2040

Solar LCOE could
reduce

46%

from 2020 to 2040

Source: McKinsey, 2021.

In addition, both wind and solar energy can be combined in the same location in Brazil (such as in the Southeast) to optimize hydrogen production projects.

*Source: Aneel/Absolar, 2022

**Source: Global Market Outlook for Solar Power, SolarPower Europe, 2022

***Considers USD 1 = R\$ 5,35

#4

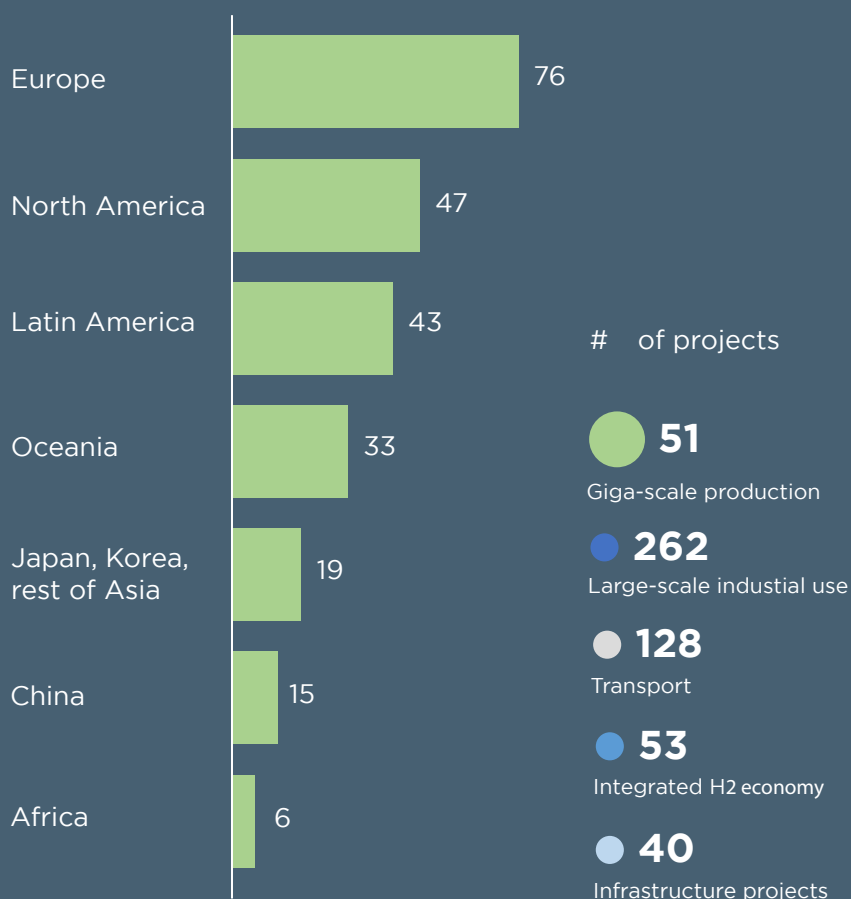
Brazil: *a strategic hydrogen hub*

Direct electrification can serve at most 60% of current energy demand in many parts of the world, so the development of hydrogen projects **appears increasingly in decarbonization strategies.**

THE WORLD ALREADY HAS 534 PROJECTS ANNOUNCED FOR HYDROGEN DEVELOPMENT UNTIL 2030 WITH USD 240 BI OF INVESTMENTS

USD 240bn

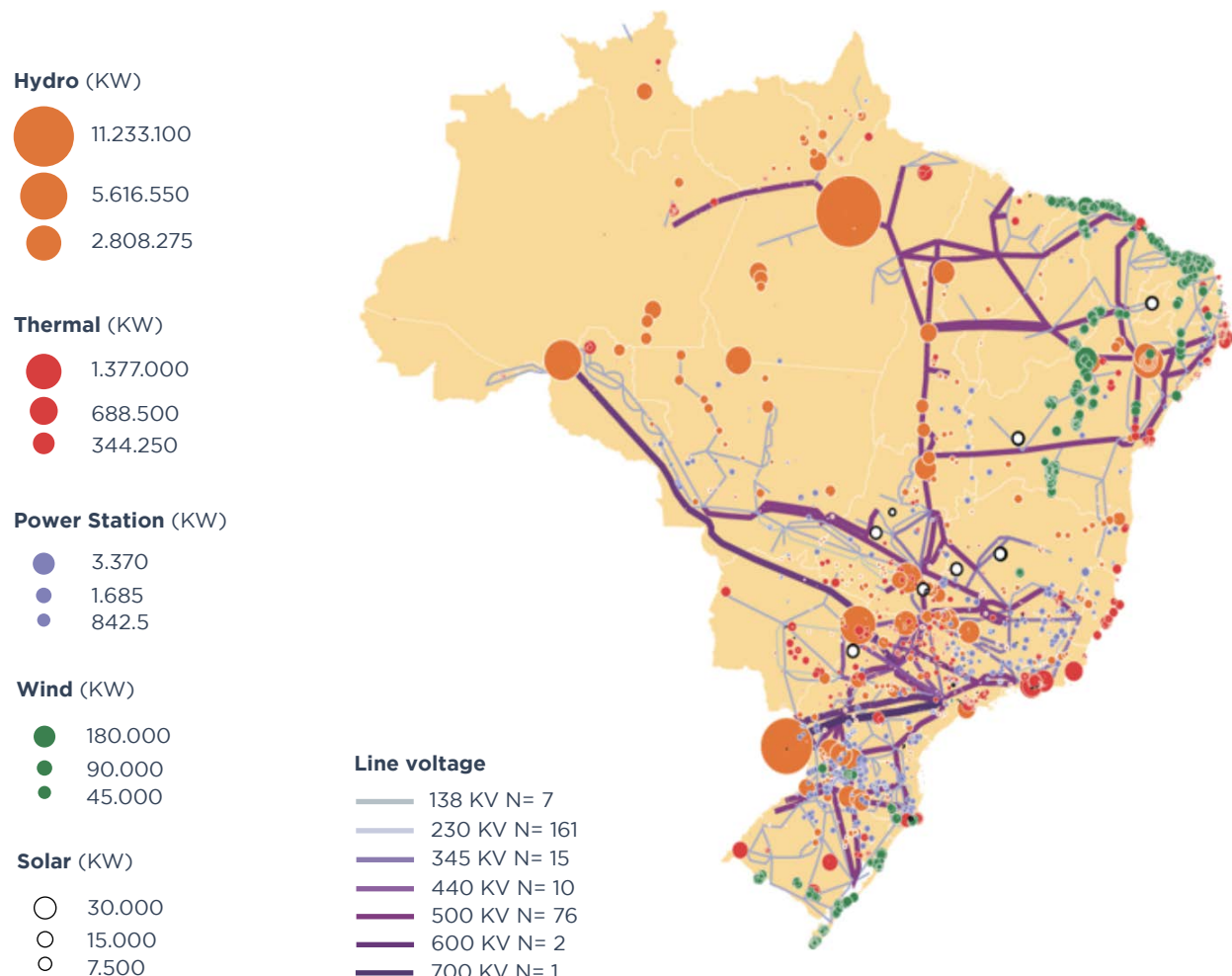
investments required for announced projects until 2030



Competitive renewable generation capacity is a fundamental condition for green hydrogen production, up to 70% of the production cost.

Since Brazil has an electricity matrix composed of **85% renewable energy**, investments for a national green hydrogen production could benefit from the existing grid. In addition, the impact of solar and wind intermittency can be mitigated by the fact that Brazil's national electricity system is fully integrated, ensuring the supply of renewable energy from other sources such as hydroelectric power.

BRAZIL'S INTEGRATED ELECTRICITY SYSTEM ALLOWS MITIGATING INTERMITTENCY OF SOLAR AND WIND GENERATION

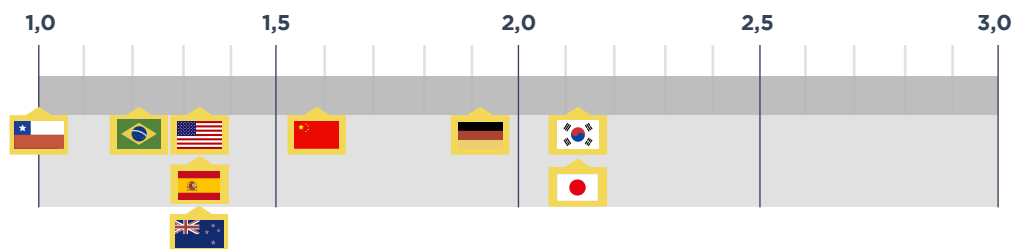


In addition, the drop in clean production costs, the greater exploration of the renewable generation potential and the efficiency gains from technological advances in small- and large-scale hydrogen production **will make Brazil achieve a significant competitiveness in hydrogen production.**

Brazil can produce green H₂ around USD 1.5/kg in 2030 and USD 1.25/kg in 2040, comparable to countries like the United States, Spain, and Australia.

BRAZIL IS AMONG THE MOST COMPETITIVE GLOBAL PLAYERS IN GREEN H₂ EXPORTS, ACCORDING TO THE LCOH BENCHMARK.

Forecast of hydrogen cost USD/kg in 2040

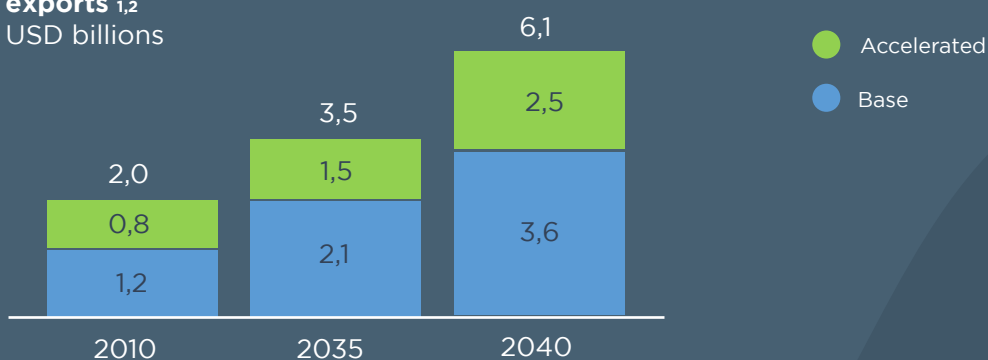


Source: McKinsey, 2021

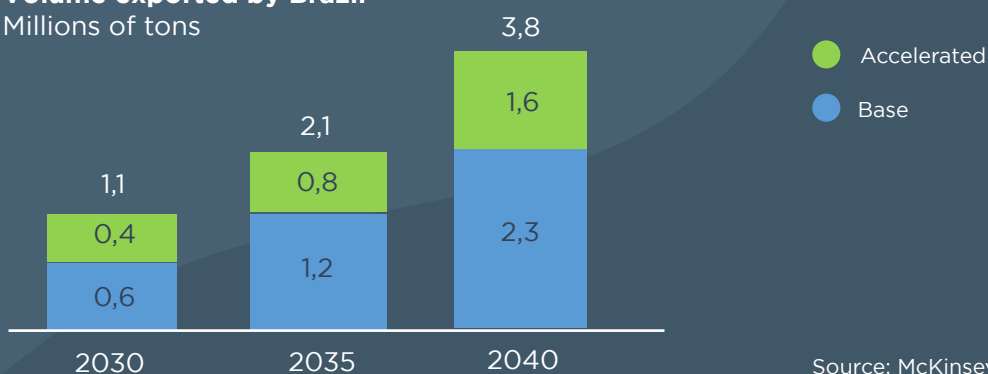
It is estimated that hydrogen production in Brazil is competitive enough to export up to 4 million tons of hydrogen in 2040 to the European Union and the United States, **capturing a market of up to USD 6 billion.**

BRAZIL CAN CAPTURE USD 6 BILLION MARKET IN THE US AND THE EUROPEAN UNION BY 2040

Total market for Brazilian exports ^{1,2}
USD billions



Volume exported by Brazil
Millions of tons



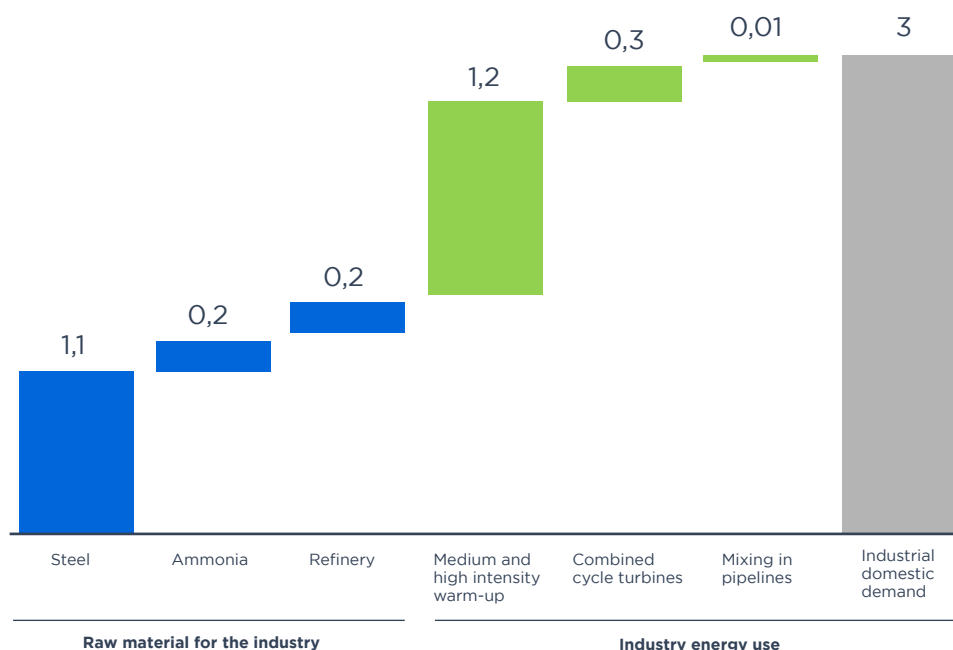
Source: McKinsey, 2021

¹ Figures reflect hydrogen production costs for projects in the NE, off-grid, at (% WACC-2030: 1.85\$/kgH₂; 2035: 1.73\$/kgH₂; 2040: 1.60 \$/kgH₂)
² If on-grid production is considered, production costs would be 10-15% lower (2030: 1.68 \$/kgH₂; 2040: 1.44 \$/kgH₂)

In addition, the Brazilian domestic market also represents an important pillar of the hydrogen production: **according to Mckinsey, Brazilian industrial demand may reach 3 million tons of H2 in 2040, considering a scenario of no carbon tax.**

This is because hydrogen, besides being an energy carrier, is an important input for industrial use, such as in the chemical, steel, and cement industries, which are considered hard-to-abate sectors, or even for the transportation sector. In this way, the domestic market can help ensure demand for H2 in the region, allowing H2 producing plants to diversify markets beyond exports.

The Brazilian industrial Market will also have a demand of 3 milion tons in 2040 in a “no carbon tax” scenario



Source: McKinsey's hydrogen service line

1 Presupposes an estimated cost of hydrogen production for SE in the grid, with WACC of 9% 1.36/kg in 2040
2 Considering the adoption of a carbon tax in 2025
3 Variations result from years of minimum and maximum TCO parity

#5

Conclusion: *Brazil gathers the main success factors for new projects in **the wind, solar, and hydrogen industries.***

Brazil is a powerhouse for accelerating sustainable business, enabling the leap that Europe is seeking into the future of energy. Renewable energy is already a reality here.

Each year they grow stronger, gaining efficiency and reducing costs.

Key Factors

■ OFFSHORE WIND INDUSTRY

#1

High incidence of wind

#2

Proximity to the **Port of Açu**, already in operation, to serve as a logistical support base, as well as for installation and commissioning

#3

Availability of low-cost area for establishing an industrial base, including areas for laydown and pre-assembly

#4

Synergy with other offshore operations at **Port of Açu (such as O&G)**

#5

Responsible management of marine space

#6

Environmental licensing

#7

Connection to the national distribution network

#8

Protected biodiversity areas



SOLAR GENERATION

- #1 High solar incidence
- #2 Availability of area at low-cost
- #3 Connection to the national distribution network



GREEN HYDROGEN PRODUCTION

- #1 Availability of water from safe (and multiple) sources
- #2 Availability of renewable energy at competitive prices
- #3 Connection and integration between on-grid and off-grid energy
- #4 Export Infrastructure
- #5 Proximity to consumer market



In Brazil, the Port of Açu is the gateway to the energy revolution. Located in the north of the state of Rio de Janeiro, close to 54% of the country's GDP, **Açu is the largest industrial port complex in Latin America** and is the place that presents all the key factors listed above to leverage the opportunities of the Brazilian market, in particular:



Scalability, with large area available for growth;



Infrastructure 100% private and ready for import or export, including a 25-meter deep draft and a terminal that enable the export of large volumes of H2 or ammonia



Favorable geographic location - close to the Brazilian economic core (54% of the GDP is in the Port region) and on the coast of one of the three offshore wind energy hotspots in Brazil



Availability of water from multiple sources for H2 production.



Long **track record of licensing greenfield projects** from conception to final installation, including a decade of environmental study and monitoring of the region;

Learn more about
how the Port of Açú
can connect you to
these opportunities

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