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ENERGY RESEARCH

Brazilian Offshore Wind Landscape

Public Report

Agenda

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I. About us

II. Brazilian offshore wind

1. Estimated potential and current development stage
2. Economics

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- Renewables
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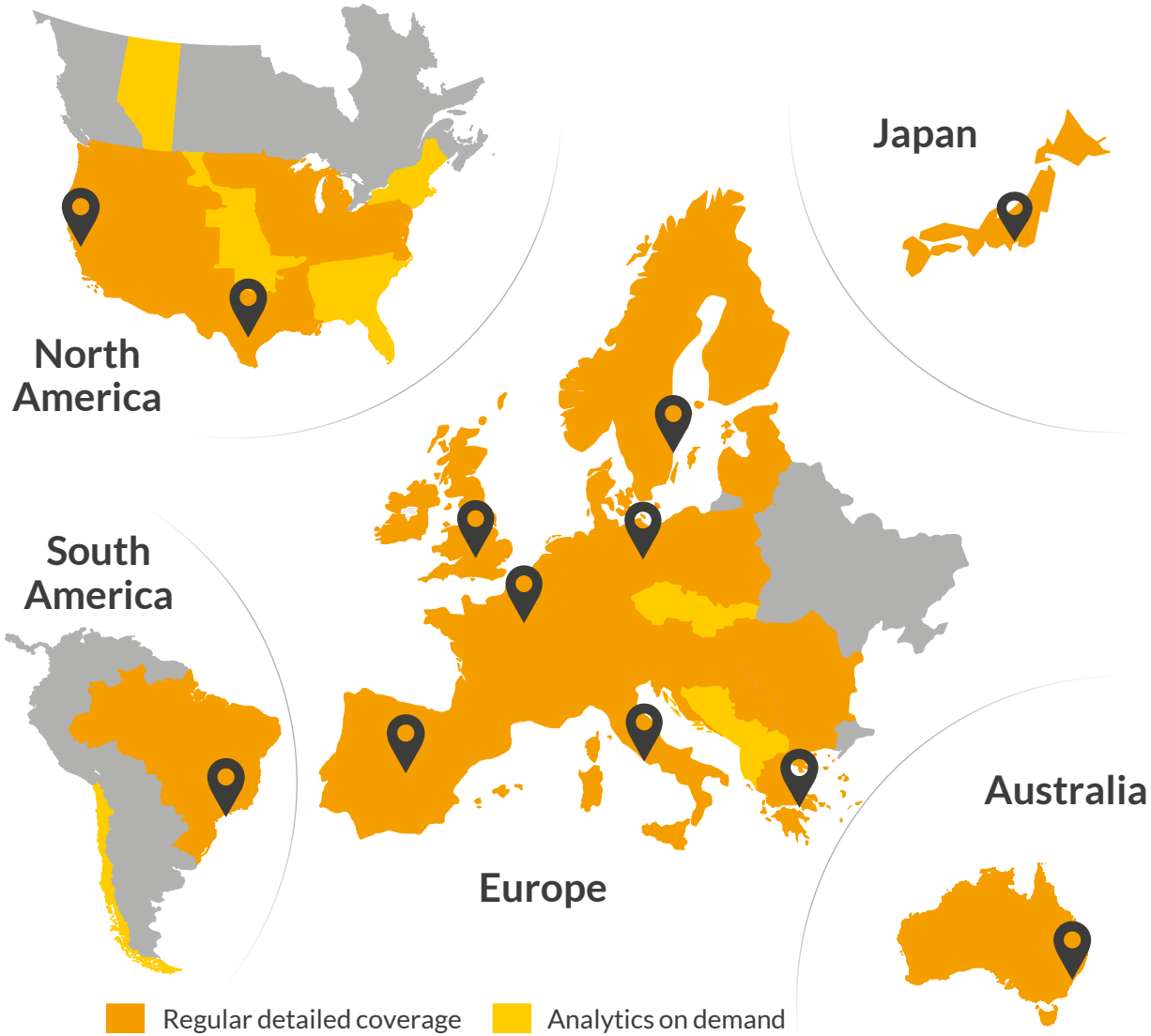

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transactions supported in 2022

Source: Aurora Energy Research

Our researchers

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Brazilian offshore potential is ~700 GW according to initial EPE estimates driven by wind speeds over 7 m/s in an area the size of Great Britain

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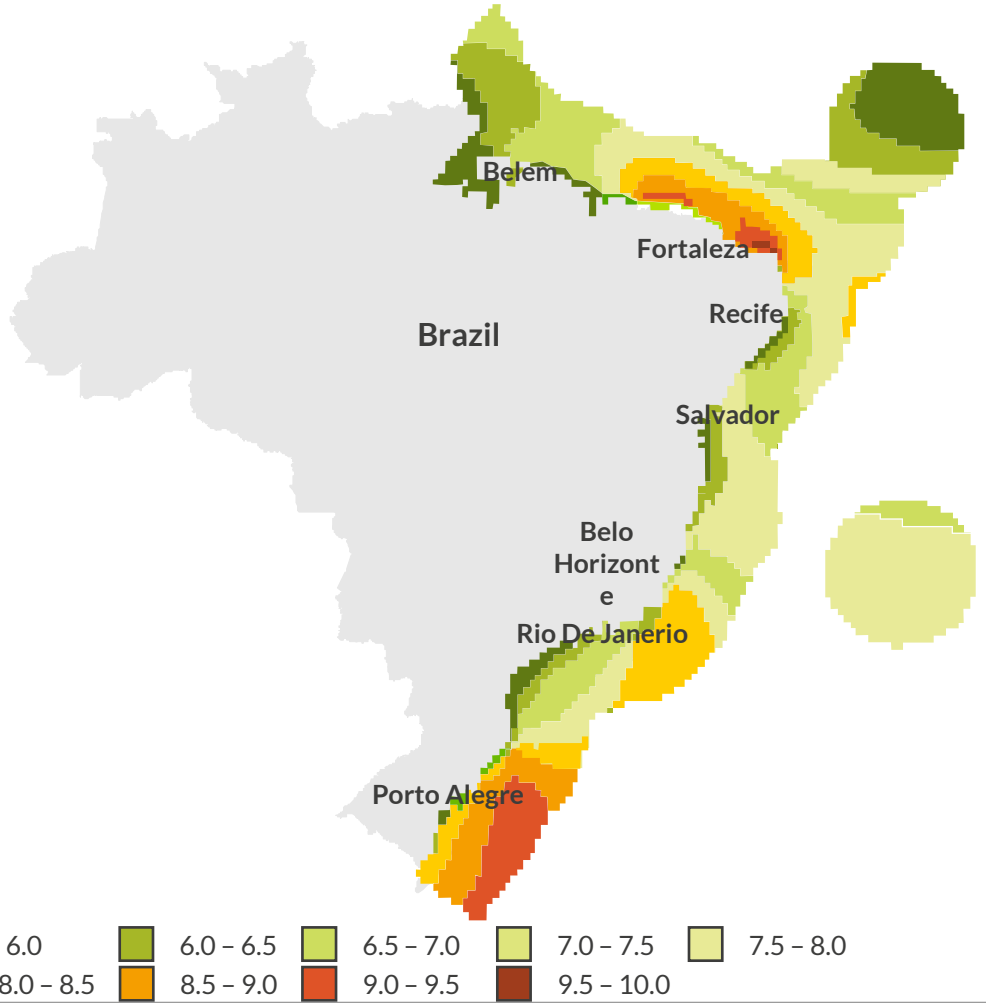
Brazilian offshore wind speeds

m/s



EPE estimates

- In 2020, the Energy Planning Bureau (EPE) published a study outlining the roadmap for wind offshore development in Brazil.
- The EPE identified areas with the highest potential for offshore wind energy production in Brazil's Exclusive Economic Zone[1]
  - There is almost 700 GW of potential available in areas that have wind measurement greater than 7m/s in an area equivalent to Great Britain.
  - The Northeast region holds 51% of the offshore wind potential, while the North region has 28%, the South 14%, and the Southeast 7%.
- The potential identified is 3.6x higher than the total current installed capacity in the country (195 GW).

	Area km²	Potencial GW	Expected load factor %	Potential TWh
South	37.106	97	37-53	371
Southeast	18.361	47	38-43	176
Northeast	94.920	356	37-62	1436
North	52.560	197	25-32	554
Brazil	**202.947**	**697**		**2.537**

1) Exclusive Economic Zone (EEZ) is a maritime zone where a coastal state has special rights over exploration and use of marine resources, up to 200 nautical miles from its coastline.

Sources: EPE: Roadmap eólica offshore

Although Brazil has a strong and clear regulatory framework related to renewable energy projects, the regulation for offshore wind is still in development

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While the current regulatory and policy framework applicable to other renewable assets, can be broadly applied to offshore wind, specific regulations regarding concessions, licensing, and permitting are anticipated to be introduced later this year

Overarching regulation	1988	Fed. constitution Art. 20	Establishes that that the territorial sea, marine land and its additions are property of the Nation.
	1988	Fed. constitution Art. 21	Defines that the Union is responsible for electrical services, which may be done directly or via authorization, concession or permission granted to other companies.
	1995	Laws 8.987 and 9,074	Provide for the process of granting concessions and authorisations for electricity generation.
	1996	Law 9,427	Determines that the **competence to grant authorisation** for wind farms, whether onshore or offshore is **delegated** to **ANEEL**.
	2004	Law 10,848	Introduced the possibility of selling wind energy to the regulated market through energy purchase auctions.
Aneel reg.	2009	Reg. resolution 389	Establishes the duties, rights, and other general conditions applicable to the granting of authorizations.
	2020	Reg. resolution 876	Establishes the requirements and procedures necessary for granting authorisation for the operation and modification of installed capacity for wind farms.
Offshore specific	2022	Decree 10,946	Regulates Art. 20 of the fed constitution in topics related to offshore power production from any source. ▪ Allows both free and fee-based allocation of offshore energy areas, depending on research or electricity generation purposes. ▪ Planned allocations to follow a bidding process, but there is uncertainty about auctions in individual allocations requested by developers outside planned allocation areas. ▪ Provides that at least nine governmental entities must be consulted to avoid interference with other activities.

The missing regulation for offshore projects should be created by various entities involved in the normative process

1 Congress: overarching regulation

- A law defining the optimal concession model still needs to be approved as uncertainties remain, especially regarding independent allocations and potential auctions.
- Bill 11,247 was introduced in 2018 to regulate the exploration of offshore wind energy and is still under discussion. Congress aims to pass the measure by the end of 2023.

2 Aneel (regulator)

- Although it is clear that offshore farms are subject to the general regulatory framework applicable to onshore farms, it is still unclear which changes are expected in existing norms. These should be reviewed under the published regulatory agenda for 2023/2024.

3 Env. Licensing (IBAMA): Unclear licensing and permitting process

- Requirements for environmental impact assessments (EIA) for offshore projects still need to be clarified.

4 EPE/MME: Transmission plans and royalties

- EPE still needs to incorporate offshore assets in its power transmission expansion plans.
- MME still needs to publish the methodology for calculating royalties and for the calculation of grant fees to be paid by developers related to offshore energy exploration.

Sources: Aneel, EPE, Aurora Energy Research

Congress has been discussing the regulatory framework that will be used to award concessions to developers

Concession models: New bill proposes two different options

Concession models

- Planned concession: exploration of a power generating asset within **areas pre-outlined by government** offered through a public selection process.
- Independent concession: exploration of a power generating asset within **areas suggested by interested parties**, **subject to the conduct of a public consultation** as provided for in Law No. 9,074/95 [1].

Studies required

- Either government (on planned concession model) or developer (on independent concession model) will have to present technical studies to grant an exploration area:
  - Technical and economic evaluation to define areas, assess project feasibility, external impacts, and their integration with local activities.
  - Prior environmental impact assessment (EIA), to be conducted for the environmental feasibility analysis of the project as part of the licensing procedure.
  - Evaluation of nautical and aeronautical safety.

Restrictions

- The establishment of offshore outlined areas (either on planned or independent concessions) is restricted and cannot coincide with:
  - Blocks tendered under the regime of oil concession or production sharing, unless carried out directly by the operator of that block (or with their consent).
  - Maritime, river, lacustrine, or aerial navigation routes.
  - Areas protected by environmental legislation.

Selection criteria

- The evaluation criteria for proposals in the selection process will be based on the highest value offered to government, including
  - Signature bonus to be paid upon the signing of the grant agreement.
  - Payment for the occupation or retention of an area, to be paid monthly from the date of the grant agreement signing.
  - Proportional participation, to be paid monthly from the date of commencement of commercial operation, in an amount equivalent to five percent of the energy effectively generated and sold for each energy framework.

1) After the public consultation, additional stakeholders may emerge, leading to potential disputes over the delineated area

Sources: Brazilian congress, Aurora Energy Research

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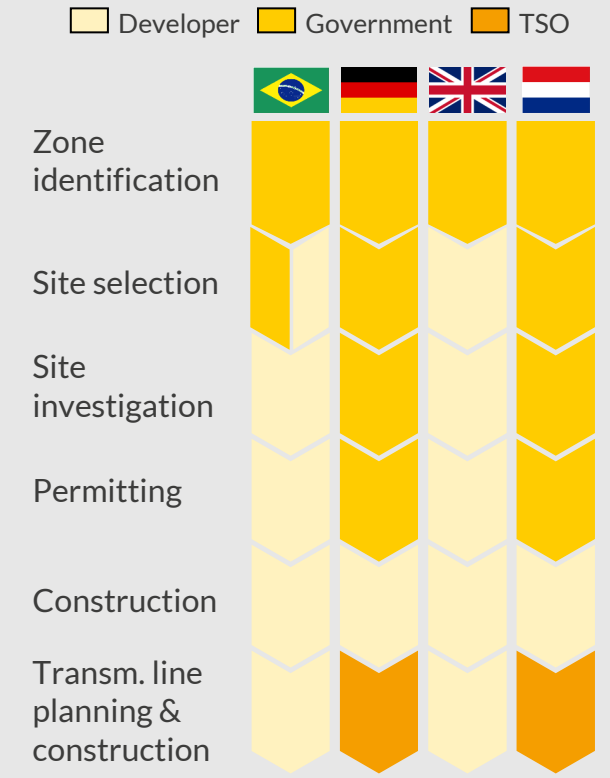
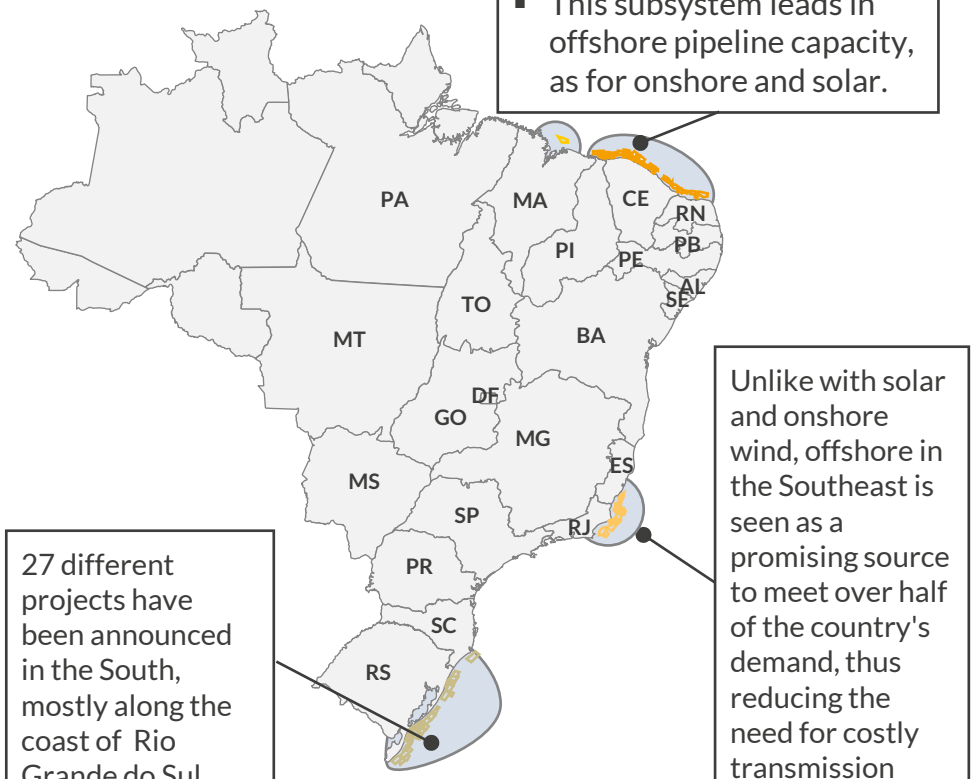
International comparison

The proposed regulatory framework is similar to that used in the UK, where the developer is responsible for carrying out most of the project steps.



219 GW of new projects have already been announced and are awaiting for the regulatory process to be approved

Projects by cluster
#

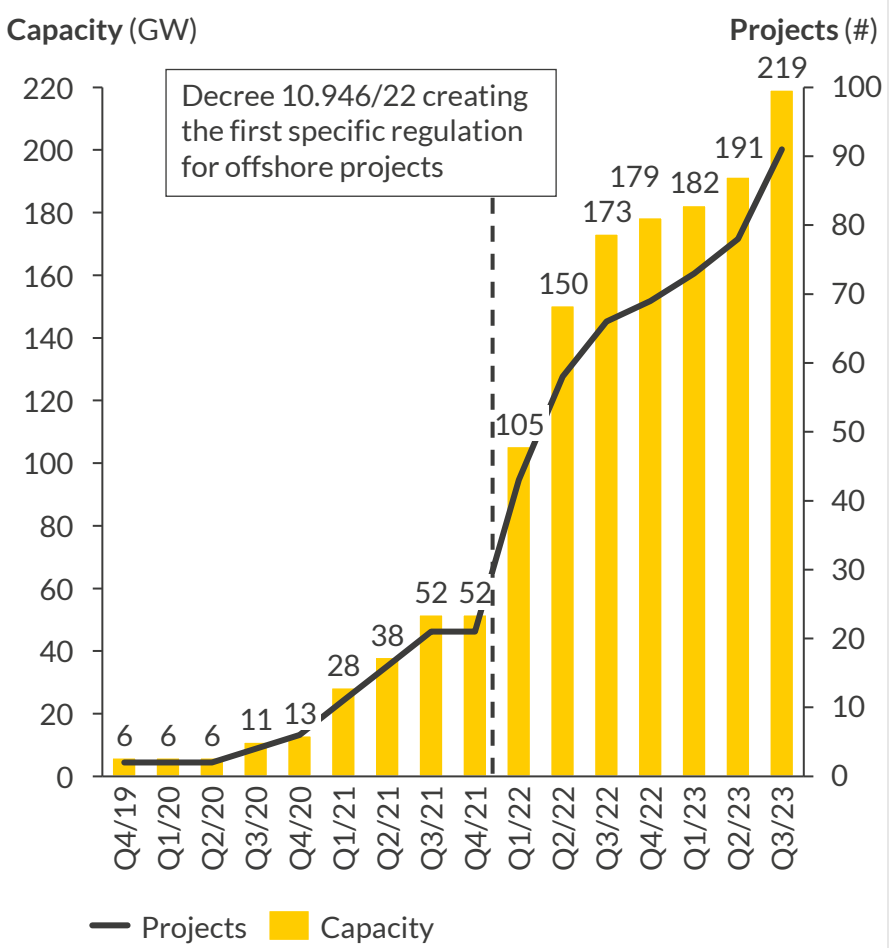


- 44% of the projects are in the Northeast.
- This subsystem leads in offshore pipeline capacity, as for onshore and solar.

27 different projects have been announced in the South, mostly along the coast of Rio Grande do Sul.

Unlike with solar and onshore wind, offshore in the Southeast is seen as a promising source to meet over half of the country's demand, thus reducing the need for costly transmission lines.

Pipeline of projects



North Northeast Southeast South

1) Independent developers have been seeking approval for environmental studies in areas of their interest. Multiple developers might be interested in the same space, leading to overlapping areas of study

Sources: IBAMA

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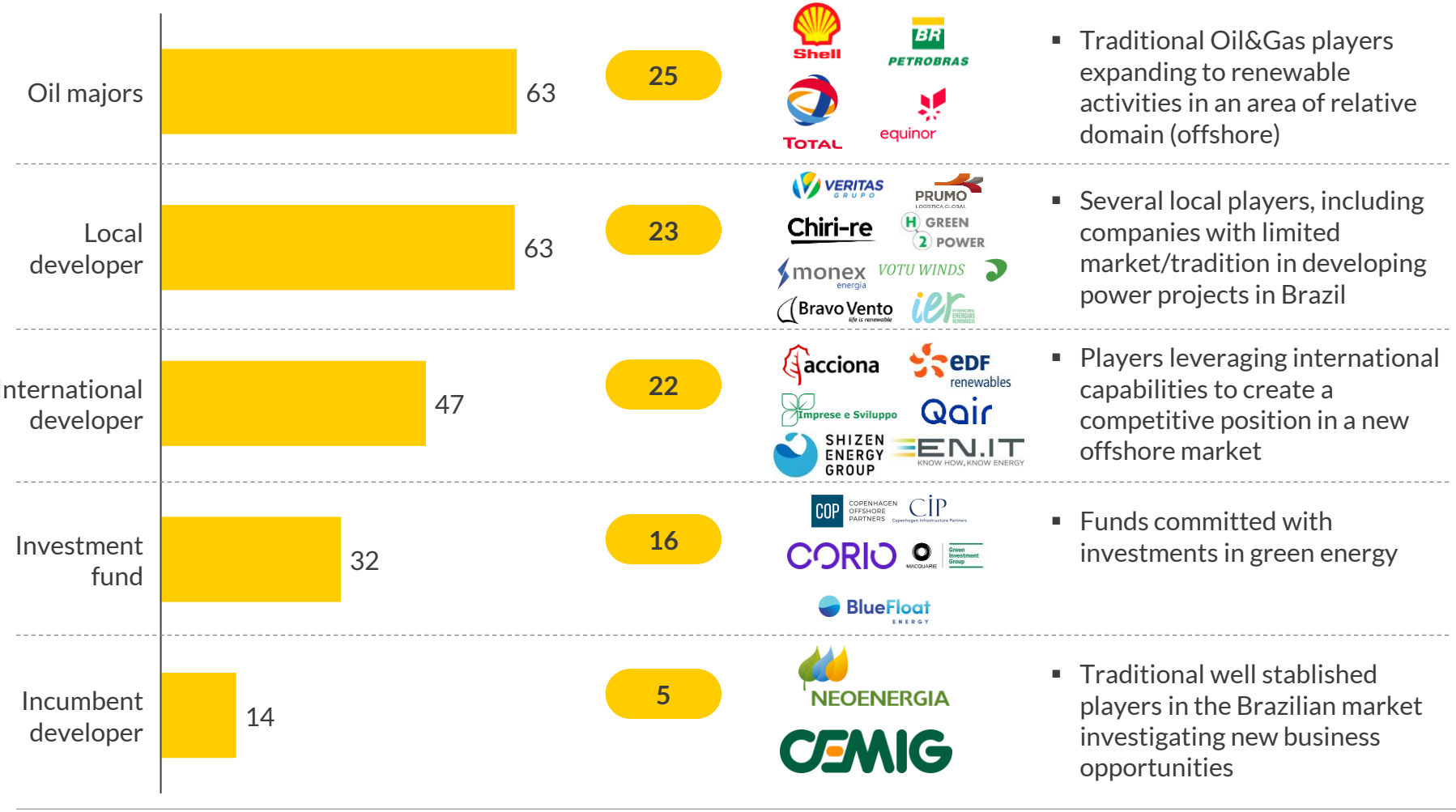
- There has been a significant **increase in the demand** for offshore project licensing **since the publication of Decree 10,946/22**
- **219 GW in 91 projects** have applied for environmental license, although 36 projects are requesting rights to explore the same or part of the same areas (90 GW[1])
- Northeast concentrates most of the pipeline with 97 GW in 43 projects, followed by the South 72 GW in 27 projects, Southeast with 44 GW in 18 projects and North with 6 GW in 3 projects
- The average size stands at 2.4 GW, with seven wind farms surpassing 5 GW.
- Most projects announced plan to use 15 MW turbines, although some plan to use turbines as large as 21 MW.
- **The environmental licensing entity is calling for clarifications regarding offshore environmental and regulatory framework.**

Oil companies are among the key players pursuing offshore wind opportunities in Brazil amid regulatory and market entry challenges



1) As of 20/Sept/2023

Sources: IBAMA

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- Oil companies are among the key players interested in offshore wind deployment given their competitive advantage in offshore operations and existing infrastructure along the Brazilian coast.
- Offshore deployment also allows to diversify activities by investing in renewables, offset emissions, and electrify operations on platforms for oil and gas exploration.
- Even though there is not a regulatory framework for the technology, this has not limited the interest from companies without active operations in the Brazilian market; we expect the market to move even faster once there is clarity on the regulatory framework.

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On an international comparison, Brazil offers a promising environment for offshore wind

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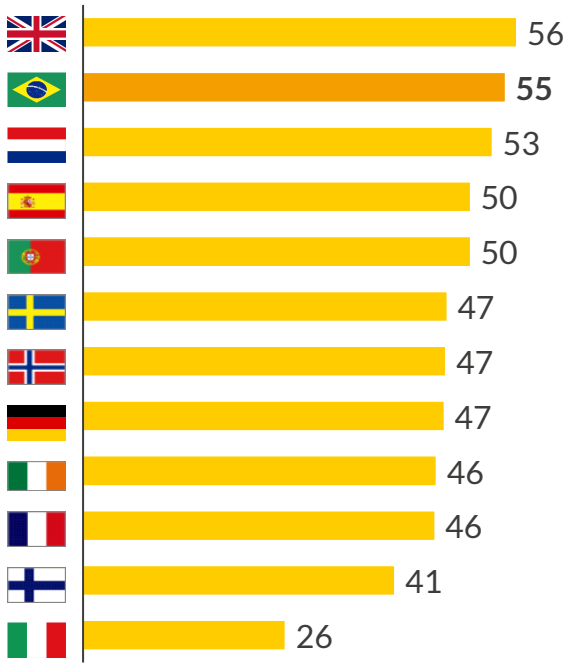
1 High load factor

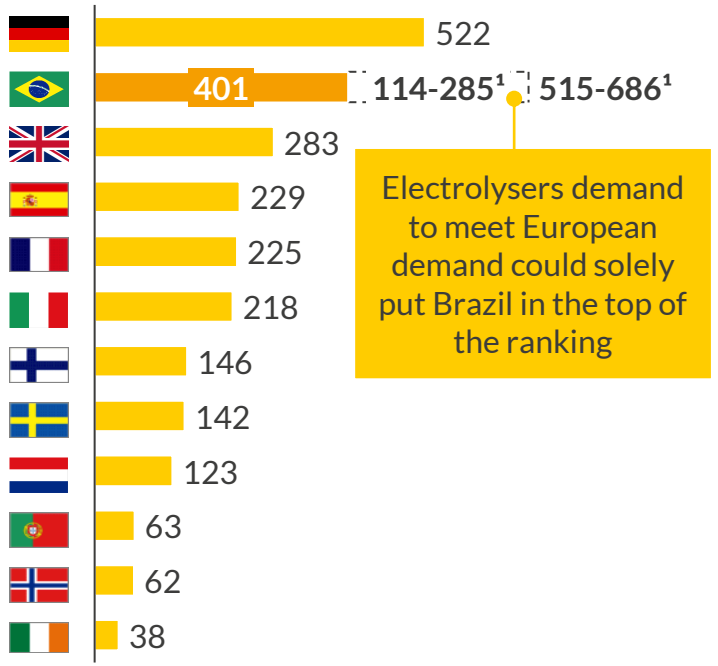
Expected load factors
2030, %



- **Brazil has one of the highest load factors expected for projects when compared to European countries**

2 High expected demand increase

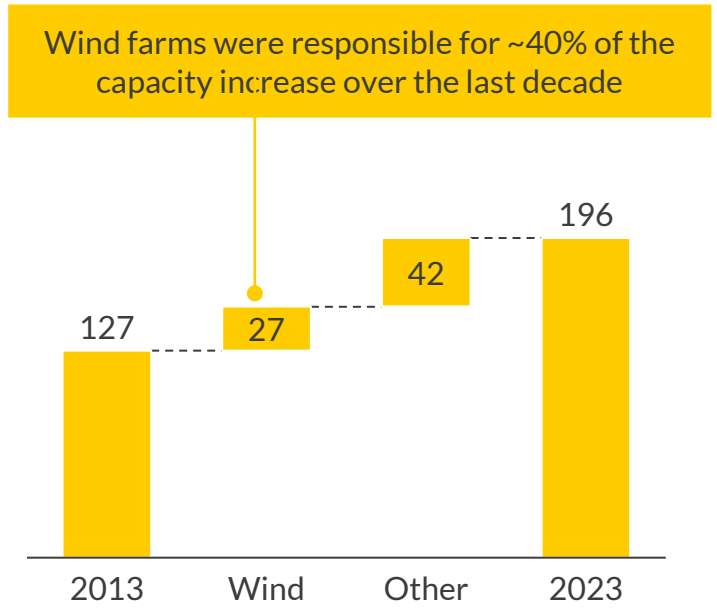
Annual demand increase
2023-2060, TWh



- **The country offers a high expected demand increase, creating a larger potential market for new renewable capacity increase**

3 Established onshore wind industry

Brazilian installed capacity at scale²
GW



- **Brazil has built a strong wind industry by mixing local manufacturing capabilities and logistics allowing imports and development of projects across the country**

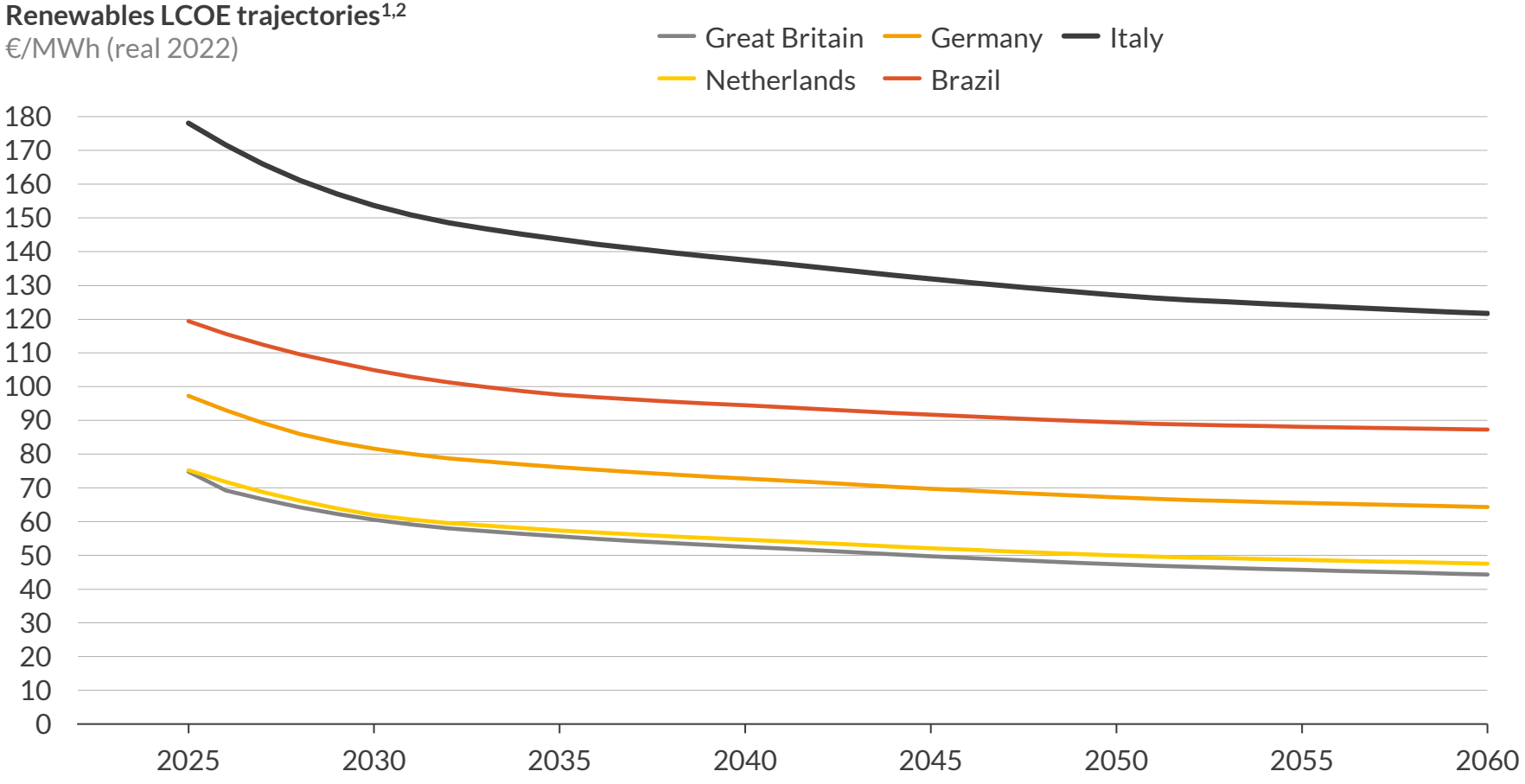
1) Assuming 56.9 TWh/MtH_2 . Assuming that Brazil would export 2-5 MtH_2 to meet 20-50% of the expected annual demand for imports from Europe 2) Does not include MMDG

Sources: Aurora Energy Research

Despite the favourable conditions, Brazilian LOCEs remain higher than in developed economies, mainly due to higher WACC and Capex

The Levelised Cost of Energy (LCOE) for renewables technologies at utility scale are shown below.

Renewables LCOE trajectories[1,2]
€/MWh (real 2022)



1) LCOEs shown for a representative location before curtailment. Includes effects of recent movements in commodity and raw materials prices. Imbalance costs are excluded; 2) LCOE are shown at Commercial Operation Date (COD) January 1st and consider 2 years construction time for wind assets with respective CAPEX taken from years prior COD; Considers 1GW utility scale
Source: Aurora Energy Research

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- The actual reduction in costs will be contingent on deployment levels in various countries
- Considering that Brazilian projects will face higher WACCs, policymakers should create conditions for the industry as part of the policy framework under discussion

Offshore Wind assumptions

- Cost declines are driven by the installation of larger turbines and technological innovation

	Capex M € /MW 2030	Capex M € /MW 2050	WACC %
	2.1	1.9	14.5
	1.7	1.4	10.5
	2.1	1.8	8.5
	1.7	1.4	8.5
	2.3	2.0	9.0

Offshore wind farm development encounters strong competition from traditional renewables, which offer cost advantages in Brazil

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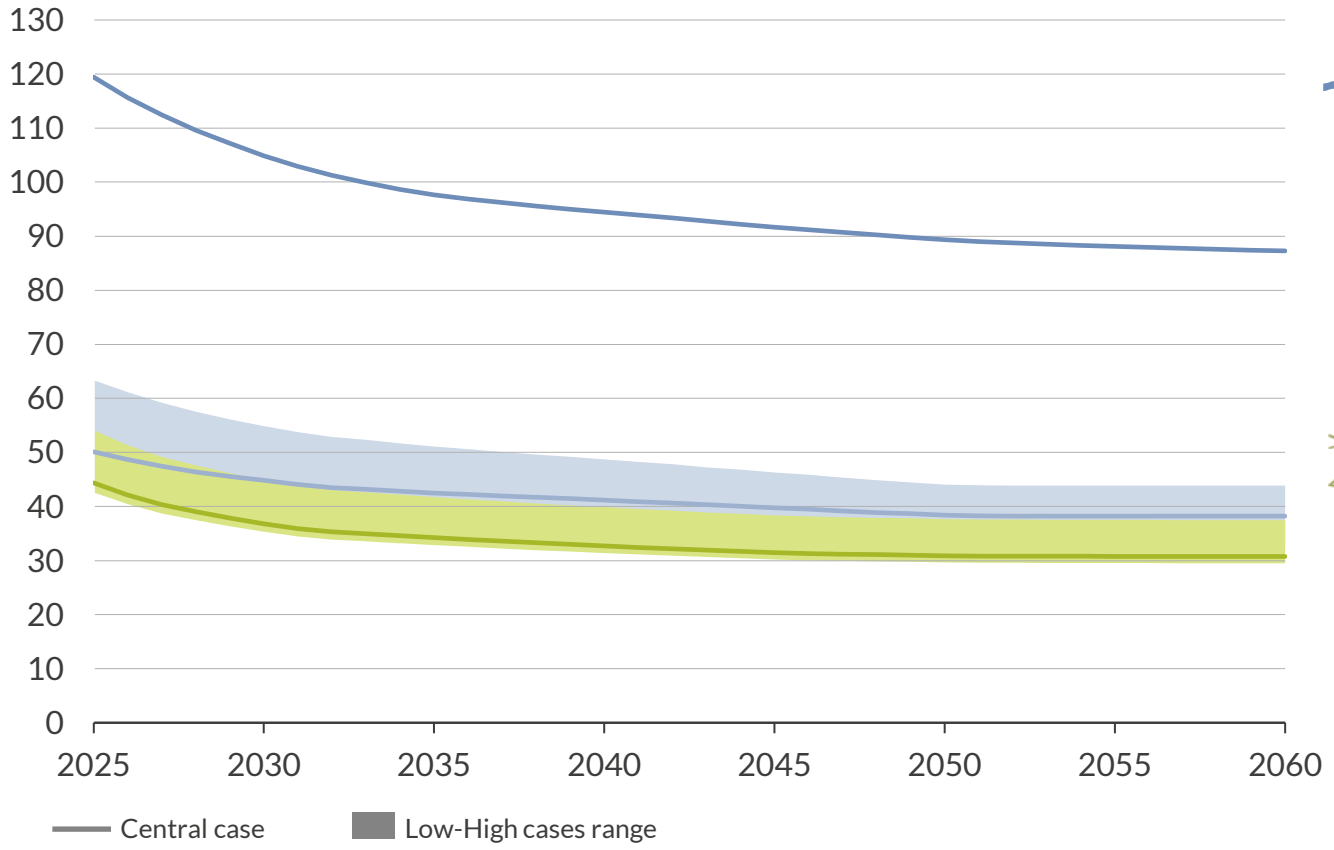

Renewables LCOE trajectories[1,2,3]

€/MWh (real 2022)

The Levelised Cost of Energy (LCOE) for renewables technologies at utility scale are shown above.

Fixed Offshore Wind

LCOE falls by 26% by 2040 driven by cost declines from installation of larger turbines and innovation from the rapidly expanding sector.

Assumptions: 1 GW utility scale, 30-year lifetime, 55-58% load factor

Onshore wind

Larger turbines and innovation in design reduce CAPEX costs and LCOE falls by 15% by 2040.

Assumptions: 100 MW utility scale, 30-year lifetime, 34-53% load factor

Solar PV

LCOE falls by 28% by 2040, driven by increases in module efficiency – this innovation leads to fewer panels to meet the same capacity. This is the most cost competitive renewable source.

Assumptions: 50 MW utility scale, 30-year lifetime, 20-25% load factor

- **Brazil offers great opportunities for renewables in general**
- **There is still available potential for onshore wind and solar farms, yet transmission lines construction may pose a challenge**
- **Get key insights to make informed decisions and make the most of opportunities by getting in touch with Priscilla Vellano, Commercial Manager**

priscila.vellano@auroraer.com

1) LCOEs shown for a representative location before curtailment. Includes effects of recent movements in commodity and raw materials prices. Imbalance costs are excluded; 2) LCOE are shown at Commercial Operation Date (COD) January 1st and consider 2 years construction time for wind assets and 1 year construction time for solar assets with respective CAPEX taken from years prior COD. 3) Assumes 14.5% WACC for Offshore wind and 12.5% for Onshore wind and solar

Source: Aurora Energy Research

To get precise data for our wind production scenarios we used our software tool Amun

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Even accounting for the additional transmission cost, the development of a Brazilian wind offshore sector will depend on government policies

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Taking into account the increased cost related to the construction of transmission lines, it is still more economical to build onshore solar and wind plants in the northeast

- The anticipated demand growth is primarily in the southern region, whereas the renewable energy potential is concentrated in the northeast.
- Offshore projects in the South-Southeast regions could serve as an alternative to new onshore renewable projects in the North-Northeast regions.
- Despite the extra transmission costs needed to supply energy to the south, onshore wind and solar projects remain more competitive than offshore projects near the load centres in southern Brazil.

	Additional interregional transmission costs[1] €/MWh (real 2022)	Local LCOE 2025[2] €/MWh (real 2022)	Power cost delivered in Southern Brazil 2025 €/MWh (real 2022)	Local LCOE 2050[2] €/MWh (real 2022)	Power cost delivered in Southern Brazil 2050 €/MWh (real 2022)
Solar Northeast	4 – 7	43	47 – 50	30	34 – 37
Wind Northeast	4 – 7	49	53 – 56	38	42 – 45
Offshore wind South		142	142	106	106
Offshore wind Southeast		146	146	109	109

Policymakers may still be inclined to promote the growth of the offshore industry to secure Brazil's position as a globally relevant player.

- The additional benefits brought by the development of offshore projects can lead the government to implement specific policies to promote the technology in the country, such as conducting specific auctions for the technology

1 Global leadership

- A robust offshore wind industry helps to position the nation as a leader in clean energy, potentially enabling trade opportunities

2 Economic growth

- New investments can foster green jobs, innovation, and new industries, driving economic growth, investments, and technological advancements, especially in the Northeast part of the country that offers a higher degree of competitiveness for offshore wind

3 Green transition

- As part of its macro green energy transition plan, Brazil may use offshore wind to promotes additional cleaner, sustainable energy sources
- A new technology should also help to diversify the energy mix, increasing overall resilience of the system

1) Additional interconnection costs of a new North-Northeast line considering 30-50% load factors (EPE 2022) 2) WACC: 12.5% for onshore wind and solar and 14.5% for offshore wind. Load factor: 25% for solar in Northeast, 45-48% for wind onshore, 45-48% for offshore wind

Sources: EPE, Aurora Energy Research

A combination of factors is expected to be decisive for the implementation of offshore technology in Brazil over the next years

1 Restrictions in new capacity builts

- Constraints on increasing transmission capacity for interconnecting the North/Northeast regions to the South/Southeast could reduce the profitability gap of offshore projects compared to onshore alternatives in the southeast.
- Specific limitations on the addition of conventional technologies in coastal areas can create opportunities for offshore power plants.

2 Government policies

- The adoption of government incentives can help catalyse new investments.
  - Tax discounts: Implementing tax discounts can reduce the implementation costs of new projects.
  - Specific auctions: Organizing auctions for the addition of offshore capacity can enable the emergence of the industry in the country, by providing revenue certainty.

3 Steeper technological cost decline

- A rapid reduction in technology costs can help make offshore projects financially viable at competitive prices over the next decades.
- Early support can help the technology to mature quicker, which should also influence the market's risk perception, potentially requiring a lower discount rate.

Sources: Aurora Energy Research

Key takeaways: Brazilian offshore wind landscape

1. Although it has not deterred investor interest thus far, the creation of a regulatory framework for offshore wind is imperative to unlock the development of an offshore wind industry in Brazil.

2. Brazilian high LCOEs for offshore wind projects are mostly determined by higher Capex and expected WACC when compared to other geographies with large offshore wind potential. A well-crafted regulatory policy has the potential to kickstart the offshore wind industry in Brazil, accelerating its development and reducing technology costs.

3. Delivering power in the southern parts of the country, where the expected load increase is located, is the key need to be fulfilled. Although the cost of building offshore wind projects in Southeast-South of Brazil may be eased by the lower transmission costs[1], developing offshore projects will remain more expensive. Policy makers may still want to foster the development of new projects to ensure a national competitive edge and boost diversification in the energy mix

Discuss how our Brazilian Power & Renewables can help your business with

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1) When compared to building renewable investments in the Northeast and building transmission lines to connect the new generation with demand centres in the Southeast

We work with a very broad range of clients … their constant challenge keeps us up on our toes and ensures our independence

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> *"With its capabilities, intellect and with its credibility Aurora plays an essential role bringing the dialogue [in the global energy transition] to a different plane"*
>
> **Ben van Beurden, CEO, Shell**

> *"Aurora analysis and the provision of reliance was crucial for our debt funding. Their ability to explain market logics and revenue streams was vital for this successful financing."*
>
> **Jeremy Taylor, Director, Green Frog Power**

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Oil & gas

ORLEN, Vitol, GASAG, equinor, eustream, OGE, SW//M Stadtwerke München, snam, bp, centrica, nationalgrid, Thyssengas, Naturgy, fluxys, Shell

Project developers

BELECTRIC, CanadianSolar, POLENERGIA, GreenFrog Power, solarcentury, brockwell energy, NEOEN, enlight, PACIFICO, tagenergy, BORALEX, British Solar Renewables, BayWa r.e., Good Energy, low carbon, BANKS Group, greentech, Invenergy, res power for good, bnrg, powercapital renewable energy, Anesco, HIVE ENERGY, TECHNIQUE SOLAIRE, EnergieKontor, lightsource bp, bp

Policy & regulation

Bundesnetzagentur, Bundesministerium für Wirtschaft und Klimaschutz, Ministerie van Economische Zaken en Klimaat, seai, Climate Change Committee, DRC Development Research Center of the State Council of the People's Republic of China, Roinn Cumarsáide, Gnóthaithe ar son na hAeráide & Comhshaoil Department of Communications, Climate Action & Environment, European Climate Foundation, European Commission, HM Treasury, Energy Regulatory Office, JETRO Japan External Trade Organization, National Audit Office, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, NATIONAL INFRASTRUCTURE COMMISSION, COMMISSION DE RÉGULATION DE L'ÉLECTRICITÉ, AEMO, LOW CARBON CONTRACTS COMPANY, Electricity Settlements Company, Department for Business, Energy & Industrial Strategy

Source: Aurora Energy Research


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