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Paving the Way for Ceará's Offshore Wind Industry

INNOWIND

July 2022

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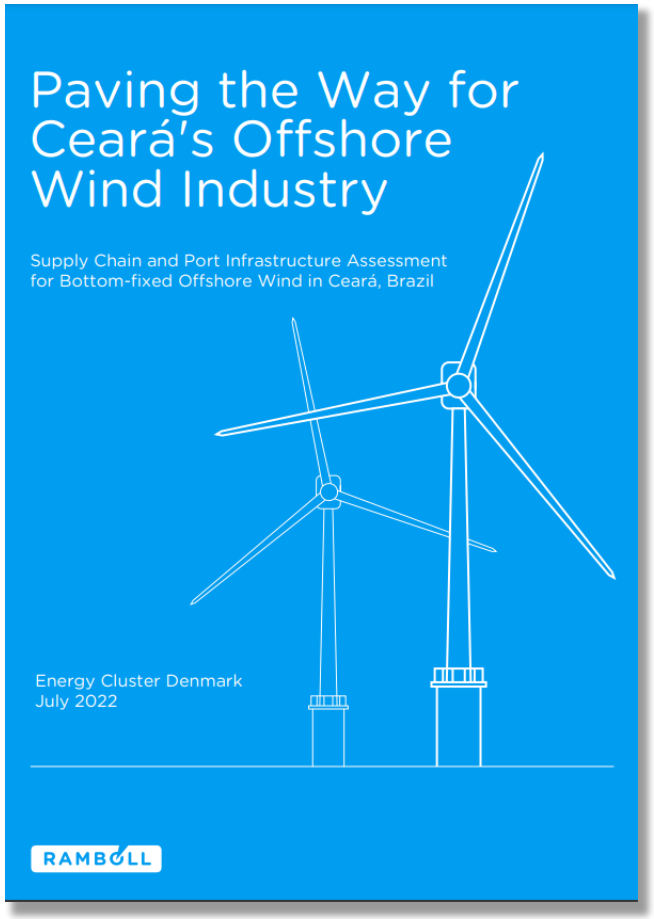
1 Introduction

Paving the way for Ceará's Offshore Wind Industry

Supply Chain and Port Infrastructure Assessment for Bottom-fixed Offshore Wind in Ceará, Brazil



This report is part of the **"Wind Energy Innovation Collaboration - Brazil and Denmark (INNOWIND Brazil & Denmark)"** innovation project, funded by the Danish Energy Agency. The INNOWIND project's purpose is to strengthen the Brazilian wind industry and supply chain through positioning Danish innovative competencies and know-how within wind energy in Brazil. Additionally INNOWIND will support the development of an innovative energy cluster in the state of Ceará, Brazil.

- The report's intent is to identify trends and larger themes, which can be used as a springboard to further policy discussions, as well as foster supplementary detailed analyses which support the emerging Brazilian offshore wind market.
- The two primary scopes of this report are a high-level opportunities and gap analysis of the Brazilian supply chain for offshore wind, as well as a high-level analysis of port suitability for offshore wind projects off the coast of the State of Ceará.

Acknowledgements

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energy CLUSTER DENMARK

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Vestas

Additionally, Ramboll would like to thank the following stakeholders for their perspectives, insights and engagement:

pecém COMPLEXO INDUSTRIAL E PORTUÁRIO

FIEC
Federação das Indústrias do Estado do Ceará

COP COPENHAGEN OFFSHORE PARTNERS

As well as thank the following stakeholder for their financial support:

Danish Energy Agency

This report was authored by Ramboll:

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2 Reference Wind Farm in Ceará

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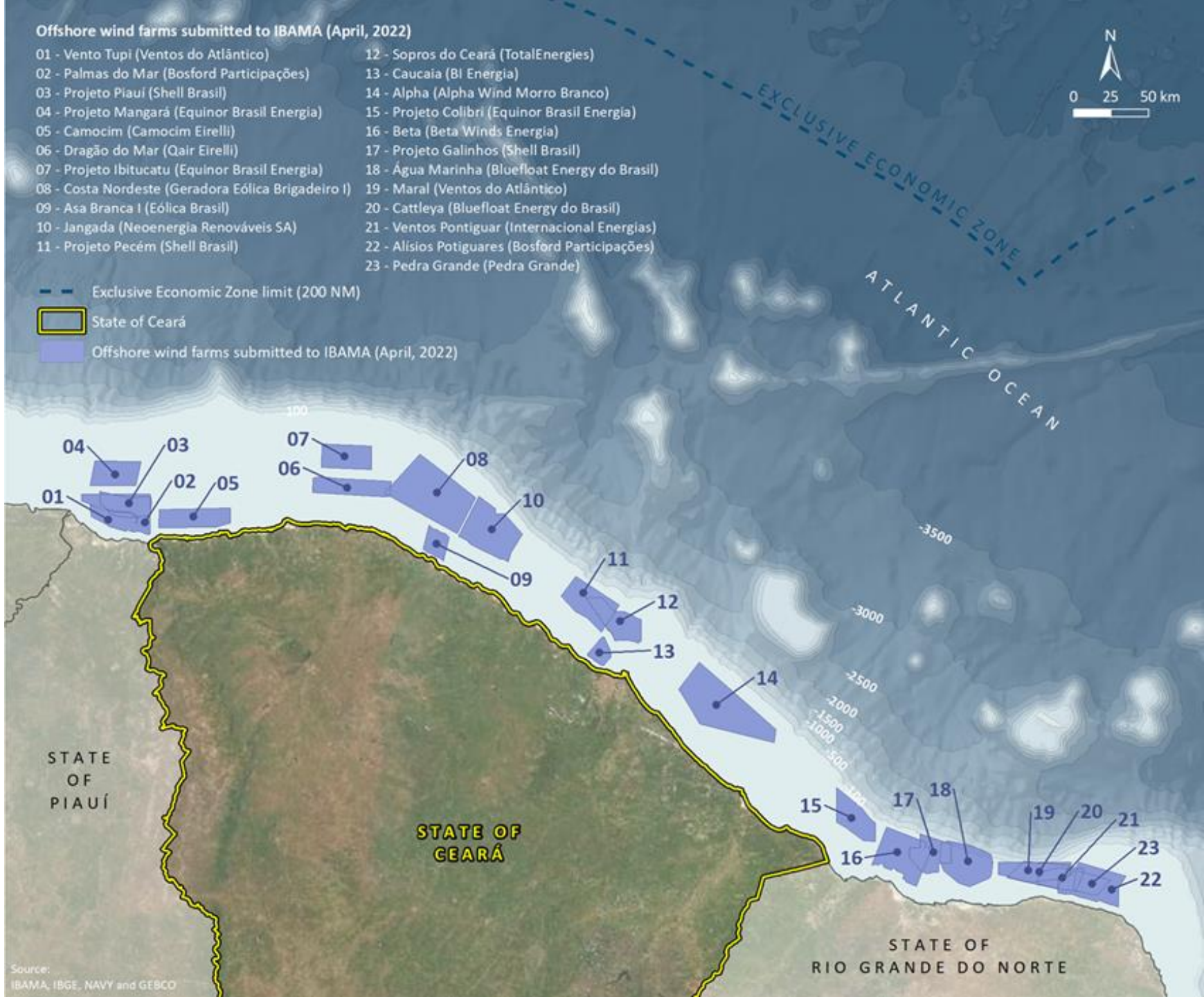
Offshore Wind in Ceará

Currently 11 offshore wind farms proposed in the waters of Ceará, with an additional 12 offshore wind farms proposed in the waters of the two neighbouring states (4 in Piauí and 8 in Rio Grande do Norte)*

- Average wind speed of the sites is 8.5 m/s (range from 8.1 m/s to 9.1 m/s)
- Average water depths of -22 m (range from -8 to -36)

*IBAMA April 2022



Ceará's Reference Wind Farm

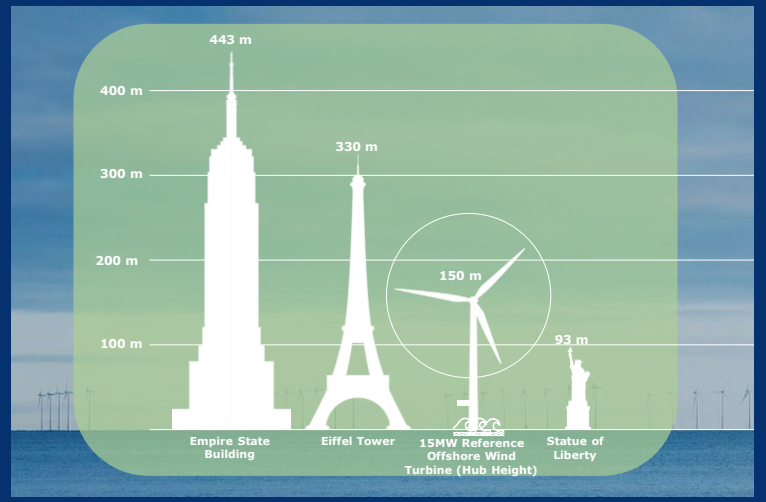
Component	Characteristic	Comment
Wind Farm Location	Offshore Ceará state, up to 50 km from the coast	Based on distance from shore of offshore site applications for the state of Ceará to IBAMA.
Commercial Operations Date (COD)	2030	Typical development times for North Sea countries with mature permitting and route-to-market regimes are in the range of 5-8 years. Uncertainties in permitting and route to market, as currently the case in Brazil, prolong these development times. Ramboll believes 2030 COD would be the earliest reasonably achievable in Brazil.
Site Water Depth	- 22 m	Ceará sites range from -8 m to -36 m, with -22 m as the average across the sites examined.
Windfarm Size	500 MW	Frequently utilized baseline for offshore wind farm studies in the industry.
Turbine Capacity	14 – 15MW range	8 of the 11 IBAMA applications filed in Ceará utilize either a 14 or 15 MW turbine.
Foundation Type	Monopile	Assuming suitable seabed conditions, the relatively shallow water depths are favorable for monopiles, which are generally the lower-cost foundation type.

Commercial Operations Date

2030

Turbine Class

14 – 15 MW



Size comparison for 15MW reference turbine used in INNOWIND report

Photo credit: Vestas

3 Supply Chain Gap Analysis

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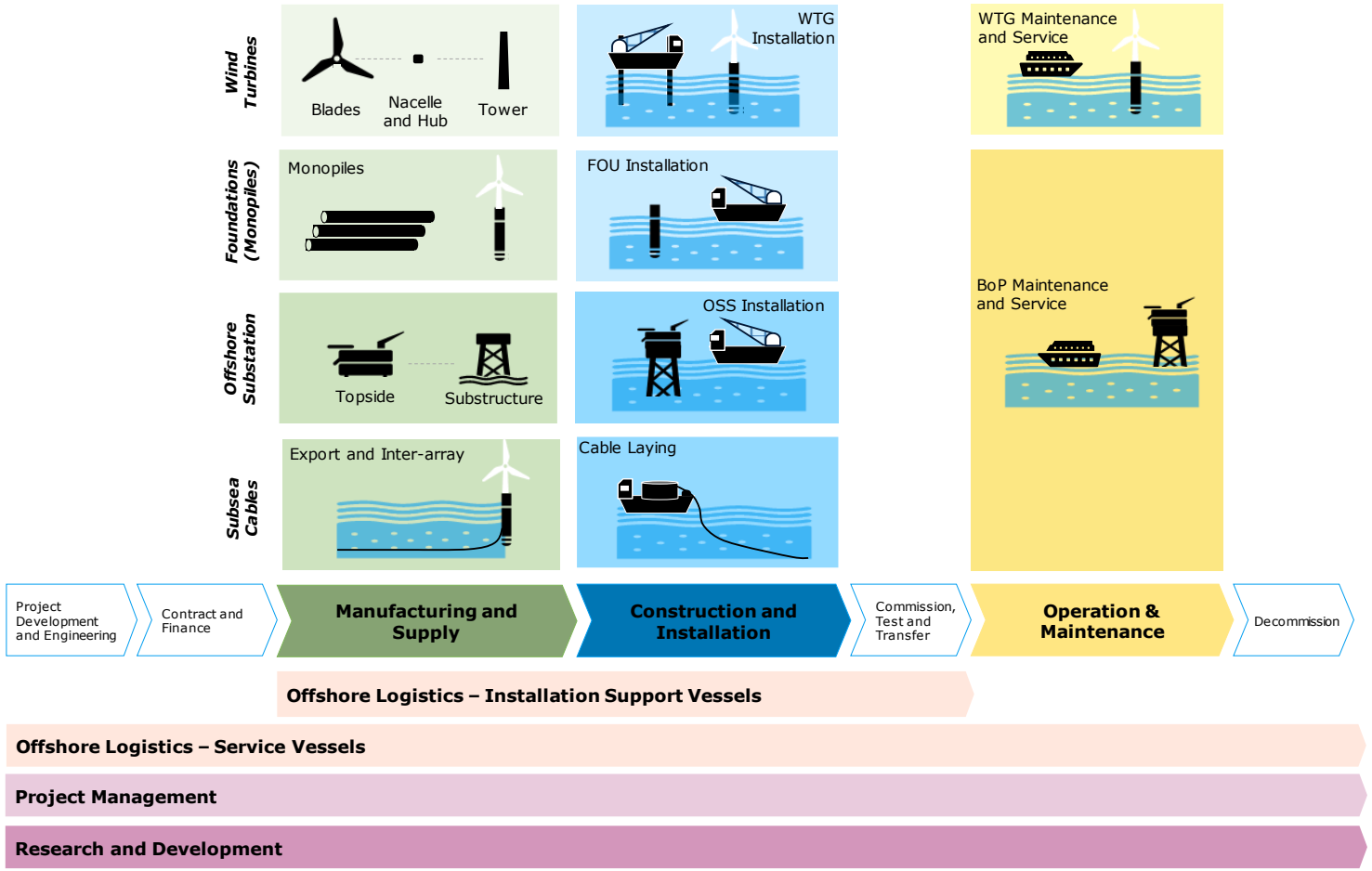
Categories Considered

Supply Chain Gap Analysis



- The supply chain analysis sections take a holistic view of the Brazilian supply chain for offshore wind to identify the key anticipated gaps and suggest recommendations on how to close them.
- This study considers that the entire Brazilian supply chain is available to support wind farms in Ceará, as European experience has shown that water transport, even over large distances, is commercially viable.
- 17 supply chain categories were reviewed as part of this analysis.

Methodology

Supply Chain Gap Analysis

- Ramboll developed a set of three criteria to assess key categories of the Brazilian offshore wind supply chain's current capabilities and potential to serve the future offshore wind farm's off the state of Ceará.
- The three criteria are:
  - Track record in offshore wind
  - Capability in related sectors
  - Natural localization potential

Criterion	Score	Description
Track record in offshore wind	**None or very low**	No experience in offshore wind
	Low	Low experience in offshore wind or additional specialized equipment needed
	Moderate	Moderate experience in offshore wind
	Extensive	Extensive experience in offshore wind, global-level supplier

Criterion	Score	Description
Capability in related sectors	**None or very low**	No capability in related sectors
	High barriers	Companies in related sectors that can enter market with high barriers
	Moderate barriers	Companies in related sectors that can enter market with moderate barriers
	Nearly market ready	Companies in related sectors that enter market without significant barriers

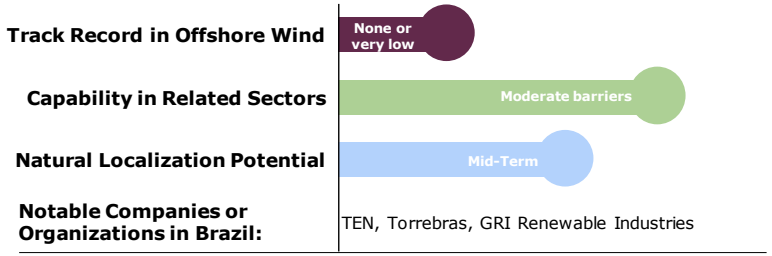
Criterion	Score	Description
Natural localization potential	**Late**	Late natural localization, cumulative installed capacity of 10+ GW
	Mid-Term	Mid-term natural localization, cumulative installed capacity of 3 – 10 GW
	Early	Early natural localization potential, cumulative installed capacity of up to 3 GW
	Local capacity exists	Local capacity already exists, and industry is strongly utilized. Potential to become a global exporter for the offshore wind industry

Opportunities (Selection from Report)

Supply Chain Gap Analysis

Wind Farm Supply

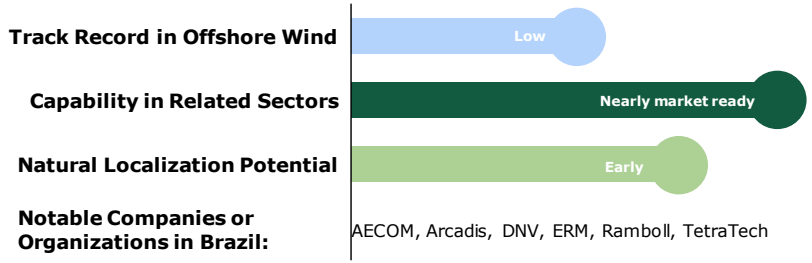
Towers



- Brazilian onshore wind does have a track record in steel tower manufacturing, however at smaller dimensions than required for offshore wind
- Brazil also has a local steel industry, which is an advantage many established tower manufacturing markets do not have
- Upgrades to waterfront facilities and equipment, as well as logistical constraints to transport the large components may slow down the localization of offshore wind tower supply

Project Management

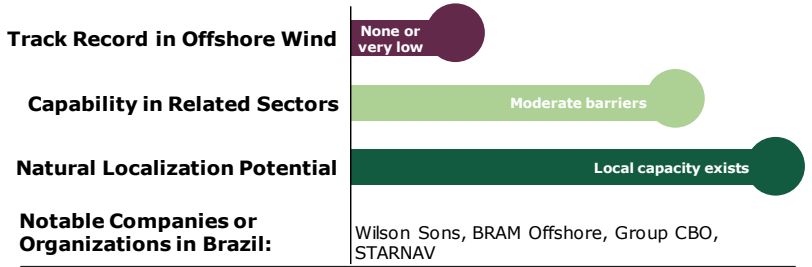
Service Providers



- Service provides are well-established for Brazil's related sectors, such as onshore wind and oil and gas, however will need to acquire specialized knowledge for offshore wind from outside of Brazil
- Service providers like AECOM, Arcadis, DNV, ERM, Ramboll and TetraTech are multinational companies with offices also in Brazil, some of which have provided offshore services elsewhere in the globe and are capable of quickly transferring knowledge to their existing Brazilian subsidiaries

Offshore Logistics

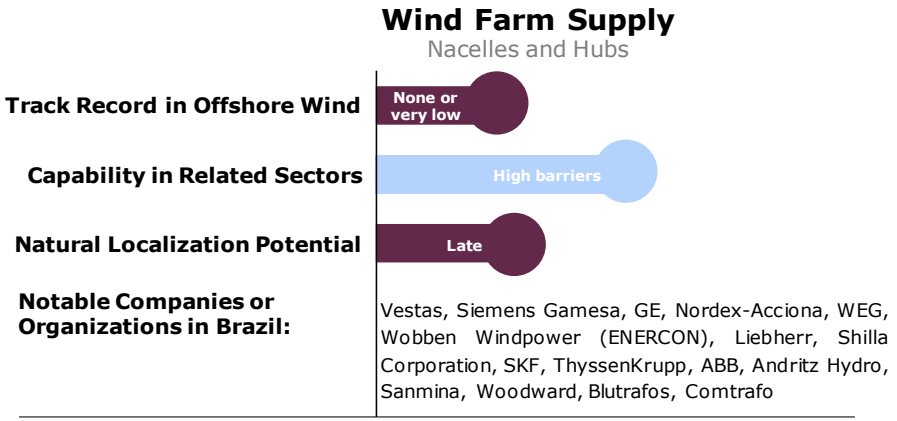
Service Vessels



- Within the past decade, Brazil's oil and gas industry began a push to increase the number of Brazilian-built and/or Brazilian flagged service vessels utilized in the oil and gas industry. The campaign was quite successful
- These vessels are not built specifically for the offshore wind industry (may sacrifice certain offshore wind-specific characteristics), however they may allow for a local offshore service vessel market
- Shipyards in Brazil are also capable of retrofitting existing vessels, for example upgrading supply vessels to add walk-to-work (W2W) with systems, or newbuilding offshore wind specialized crew transfer vessels

Gaps 1/3 (Selection from Report)

Supply Chain Gap Analysis



- High value components for the wind turbine manufacturers
- Three primary offshore wind turbine manufacturers: Vestas, Siemens Gamesa Renewable Energy, and GE Renewable Energy. Each of these players has already secured their manufacturing capability in Brazil within onshore wind.
- In the global offshore wind market, nacelles and hubs are supplied from few, select locations. Offshore wind increases the sizes of the components significantly as well as requires waterfront fabrication, which prevent current manufacturing facilities from being used.
- For nacelles and hubs, high barriers are expected, requiring an estimated pipeline of at least 10 GW of projects before a local supply chain would begin to develop.

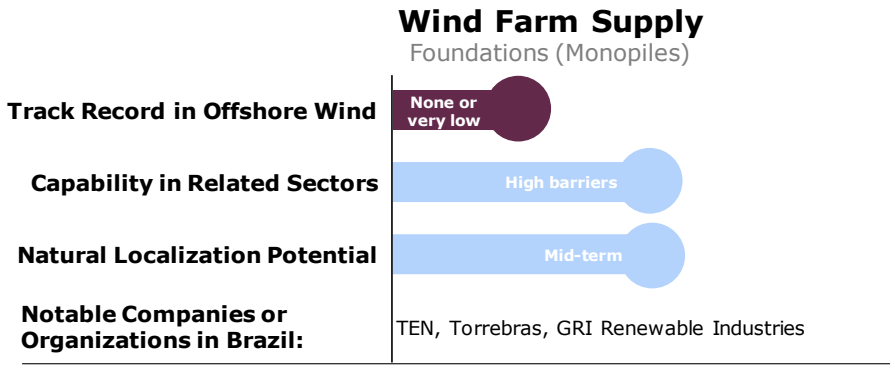
DANISH EXPERTISE

Experience and export will be needed to help scale up to offshore wind dimensions.

Denmark is home to **Vestas**, a key turbine supplier, who is also actively engaged in the Brazilian market, as well as companies such as **LM Wind Power** a multinational blade fabricator, **Welcon** the tower fabricator, as well as system suppliers like **KK Wind Solutions**, **Jupiter Bach** and **Mita-Teknik**.

Gaps 2/3 (Selection from Report)

Supply Chain Gap Analysis



- Brazil does not have a monopile industry, though suppliers of rolled tubes may be able to enter the offshore wind market, however with high barriers. For example, this may include onshore wind turbine tower manufacturers.
- The primary challenges in such a transition are the investments in waterfront facilities with ample storage space, larger or new equipment for rolling of plates with significantly larger diameters and wall thicknesses, as well as training of workforce.
- For monopile foundations, high barriers are expected, requiring an estimated pipeline of 3 – 10 GW of projects before a local supply chain would begin to develop.

DANISH EXPERTISE

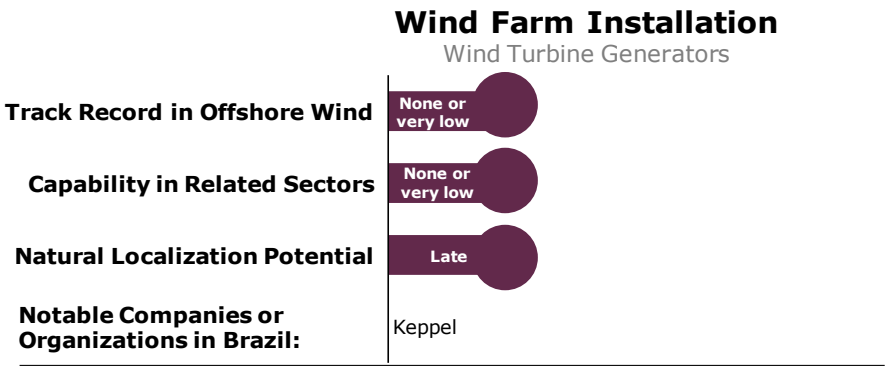
Experience and knowledge sharing will be needed to transition existing industries into monopile fabrication.

Brazil does have onshore wind tower manufacturing, steel structure fabrication from shipbuilding and oil and gas, as well as raw materials, however has not yet translated this for monopile fabrication.

Bladt Industries is an example of a Danish company, who is a key player in the industry for fabrication of both monopiles and transition pieces.

Gaps 3/3 (Selection from Report)

Supply Chain Gap Analysis



- The installation of a wind turbine generator (WTG) is performed utilizing a specialized jack-up vessel, also known as a wind turbine installation vessel.
- Globally, these vessels are in high demand, as only a handful are in operation, and even a smaller number are poised to handle growing turbine component sizes. No suitable vessels are currently available in Brazil.
- This gap is a global offshore wind identified bottleneck and therefore not specific to Brazil.
- Brazilian options may include local new-build vessels or retrofit of existing Brazilian vessels. Both options are very expensive and require specialized shipbuilding capacities.

DANISH EXPERTISE

International vessels and service providers will be required for safe and proper installation of WTGs in Brazil. Danish companies have a long history in transport and installation.

Danish **Cadeler** operates two jack-up vessels with a robust history of installing turbines. Cadeler is also constructing a new generation of vessels for 15MW + turbines.

A2Sea, now part of **DEME Group**, was headquartered in Denmark. Furthermore, Danish companies, such as **K2 Management** and **Ramboll** have extensive experience in managing T&I of components and Danish companies such as **Blue Water Shipping** hold extensive experience in offshore logistics.

Photo credit: Port of Pecém

4 Port Infrastructure Assessment

Port Infrastructure Assessment

- The port infrastructure assessment analyses the readiness and adequacy of port infrastructure to serve offshore wind farms in Ceará.
- The screening looks both at the short-term and long-term potential for installation ports using a port benchmark.
- The port benchmark differentiated between the "recommended" and "acceptable" benchmark criteria.
  - Recommended: ports aiming to be a windfarm installation hub which enable a large variety of transport and installation (T&I) setups, e.g. ports aiming to function as a logistic harbor for consecutive projects.
  - Acceptable: ports which would enable the development of a windfarm, however have a significant impact on the T&I strategy, through e.g. limiting the variety of vessels that can be mobilized.

Offshore Wind in the Port of Esbjerg, Denmark

Installation Port Benchmark

Component	Recommended	Acceptable
Maritime access		
Distance to lease area	< 100 Nautical Miles	< 200 Nautical Miles
Air draft limitation	No	100 m
Loading and pre-assembly operations		
Quay length	300 m	200 m
Quay bearing capacity	40 mt/m2	10 mt/m2
Water depth at quayside	15 m	10 m
Storage capacity		
Storage capacity	> 16 ha	> 10 ha
Storage bearing capacity	10 mt/m2	5 mt/m2

Installation Port Findings

Port Infrastructure Assessment

INSTALLATION PORTS CONSIDERED

Within 200 nautical miles of the wind farm sites off Ceará's coast

- Itaqui / São Luis in Maranhão
- Pecém in Ceará
- Fortaleza in Ceará
- Natal in Rio Grande do Norte
- Suape in Pernambuco

	Port of Itaqui / São Luís	Port of Natal	Port of Pecém	Port of Fortaleza	Port of Suape
Maritime access	**Suitable**	Air gap restriction	**Suitable**	**Suitable**	High distance to wind farm sites
Loading operations	Suitable with moderate upgrades	Suitable with moderate upgrades	**Suitable**	**Suitable**	Suitable with moderate upgrades
Storage capacity	Not suitable	Not suitable	Suitable with moderate upgrades	Suitable with moderate upgrades	Suitable with moderate upgrades
Overall suitability	Unsuitable	Unsuitable	Suitable with moderate upgrades	Suitable with moderate upgrades	Suitable with moderate upgrades
Upgrades needed for one reference wind farm	-	-	• Jack-up workability at quayside	• Jack-up workability at quayside	• Jack-up workability at quayside • Ensure storage availability
Upgrades needed to become installation hub	-	-	• Develop hauling capacity between breakwater and upland or add area to quayside • Increase load-out capacities (bearing capacity, Ro/Ro and pre-assembly cranes)	• Increase storage and load-out capacities (bearing capacity, Ro/Ro and pre-assembly cranes)	• Increase storage and load-out capacities (bearing capacity, Ro/Ro and pre-assembly cranes)

Suitable Ports

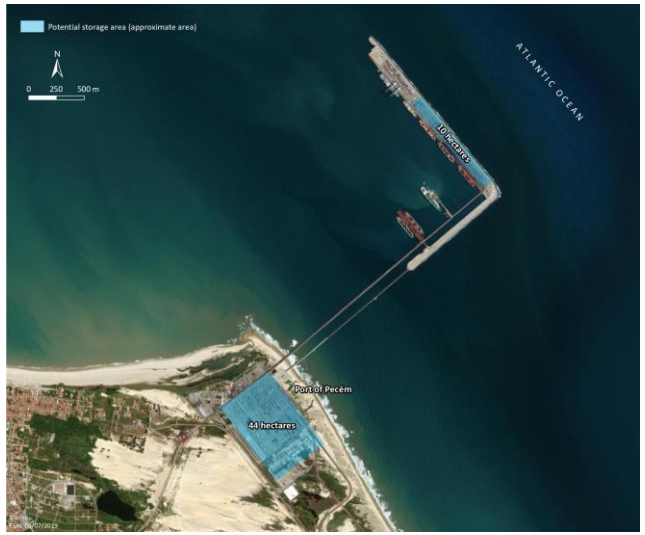
Port Infrastructure Assessment

Port of Fortaleza

- Central position on the Ceará coast: All wind farm sites in Ceará are within 200 nautical miles
- Current infrastructures are missing loadout assets such as heavy-duty cranes or Ro/Ro ramps. This can be solved by transporting windfarm components with heavy lift cargo vessels. The quaysides are suitable for transport vessels
- Working area of approximately 30 hectares identified (above) is partially in use. Spatial extension of the port area is not considered possible, as the area around the port is already developed

Both ports are suitable for the development of a 500MW windfarm without major upgrades, however limited to one component campaign at a time due to storage (in current state).

Either requiring both ports to be used for one wind farm, or subsequent campaigns, significantly extending installation time.



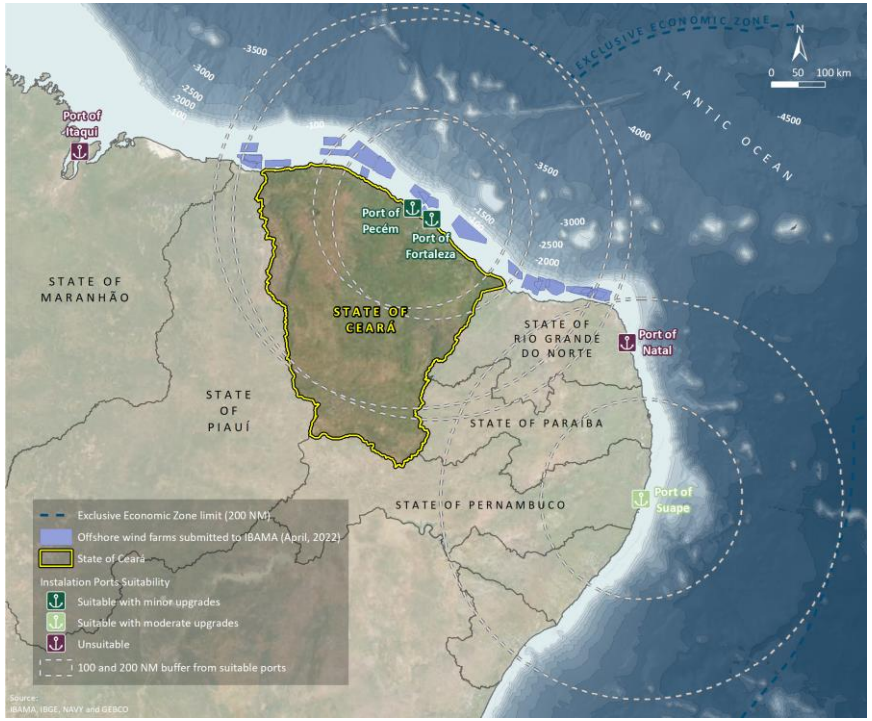
Port of Pecém

- Central position on the Ceará coast: All wind farm sites in Ceará are within 200 nautical miles
- Current infrastructures are missing loadout assets such as heavy-duty cranes or Ro/Ro ramps. This can be solved by transporting windfarm components with heavy lift cargo vessels. The quaysides are suitable for transport vessels
- Working area available on the quayside of approximately 10 hectares identified (above) located on the breakwater. Large onshore storage areas available via bridge, however transport of components via bridge shall be investigated

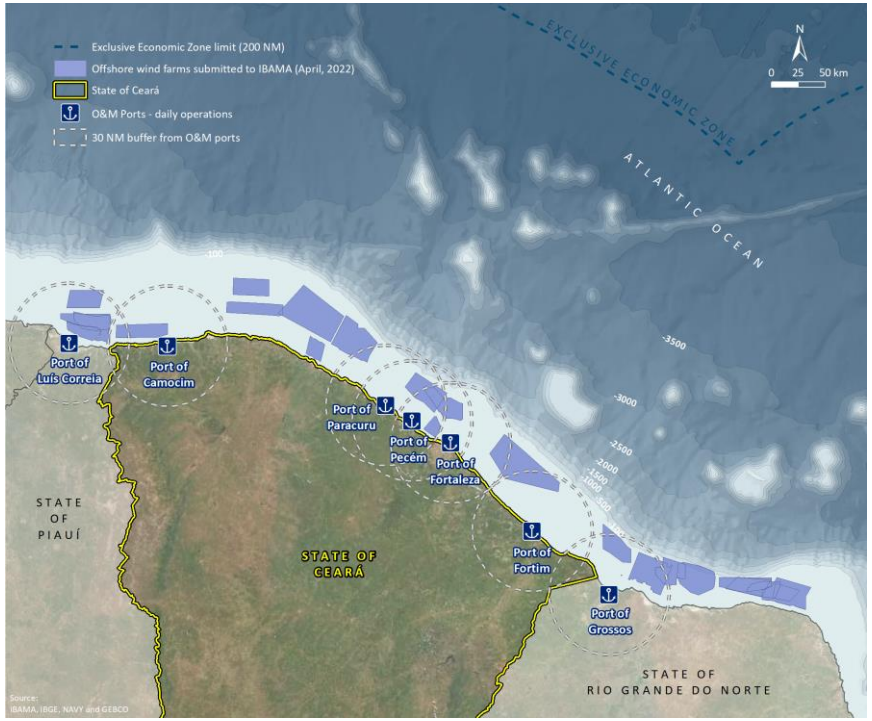
Coverage for Planned Offshore Wind Farms

Port Infrastructure Assessment

INSTALLATION PORTS



OPERATIONS PORTS



INSTALLATION PORTS

Within 200 nautical miles of the wind farm sites off Ceará's coast

- Well covered for all wind farms planned off coast of Ceará
- Wind farms off coast of Piaui will also require coverage due to no suitable ports in state

OPERATIONS PORTS

Within 30 nautical miles for daily operations, or 200 nautical miles for major repairs

- Quite well covered, however gap between Port of Camocim and Port of Paracuru

Operations Ports

Port Infrastructure Assessment

Operation and Maintenance Port Benchmark

Component	Major Repairs	Daily Operations
Distance to wind farm	< 200 Nautical Miles	< 30 Nautical Miles
Air draft limitation	100 m	10 m
Quay length	150 m	40 m
Water depth at quayside	10 m	3 m
Storage capacity	> 3 ha	> 2 containers

Findings

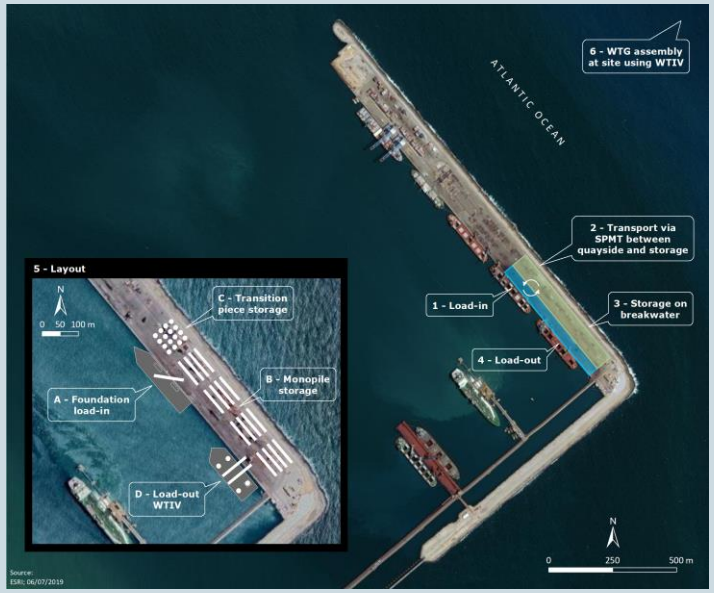
Location	Current Use	Suitable for Daily Operations?	Suitable for Major Repairs?	Comments
Sao Luis	Light cargo harbor		✓	Long distance to windfarm
Luis Correia	Fishing and some leisure	✓		Not suitable for vessels other than CTV
Camocim	Fishing and some leisure	✓		Not suitable for vessels other than CTV
Pecém	Multi-cargo harbor	✓	✓	Centrally located
Paracuru	O&G harbor	✓	✓	Centrally located, SOVs only
Fortaleza	Multi-cargo harbor	✓	✓	Centrally located
Fortim	Fishing and some leisure	✓		Not suitable for vessels other than CTV
Grossos	Fishing and some leisure	✓		Not suitable for vessels other than CTV
Port of Natal	Multi-cargo harbor		✓	Long distance to windfarm, SOVs only
Port of Cabedelo	Oil and gas and multi-cargo harbor		✓	Long distance to windfarm
Port of Suape	Multi-cargo harbor		✓	Long distance to windfarm

Case Study Port of Pecém

Port Infrastructure Assessment

- The Port of Pecém was a natural candidate for such a case study, as it has been actively interested in offshore wind in Brazil for some time and in dialogue with the INNOWIND project partners.
- The case study looks at two scenarios (for offshore wind installation) for the Port of Pecém:
  1. A utilization plan for the port using its current infrastructure to host the transport and installation (T&I) activities for a single 500 MW wind farm
  2. An upgrade and utilization plan for transforming the port into a regional offshore wind hub for T&I, which is also capable of serving as the installation port for multiple wind farms at once:
     - Alternative 1 – Upgrade of Current Infrastructure
     - Alternative 2 – New Construction of an Offshore Wind Terminal

Utilizing Current Infrastructure for a Single 500MW OWF



Upgrading the Port to Serve Multiple Farms at Once

Alternative 1

Alternative 2

5 Questions and Discussion

Thank you for your attention!

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GET IN TOUCH

Lisa Keaton

Team Lead Project Development & Advisory
Offshore Wind, Germany
lisa.keaton@ramboll.com

Raya Peterson

Head of Project Development & Advisory
Global Wind
raya.peterson@ramboll.com

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