



**PRELIMINARY MULTICRITERIA ANALYSIS OF OFFSHORE WIND POTENTIAL IN
SALINÓPOLIS PARÁ
ANÁLISE PRELIMINAR MULTICRITÉRIO DO POTÊNÇIAL EÓLICO OFFSHORE EM
SALINÓPOLIS PARÁ**

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ABSTRACT

This paper presents an enhanced multi-criteria assessment of offshore wind energy potential in Salinópolis, Pará, situated in Brazil's eastern Amazon coast. The approach integrates geospatial techniques, environmental exclusion layers, and technical-economic parameters to support renewable energy planning. High-resolution data (5 km) from the Global Wind Atlas (wind speed at 100 m), CEPEL (2017), and CPRM (2018) were employed, including bathymetric constraints and port accessibility. Monthly climatic series (1991–2021) were integrated into GIS platforms (QGIS and ArcGIS), and decision-making was structured through the Analytical Hierarchy Process (AHP), following the frameworks by Silva (2019) and Ho et al. (2018). Exclusion zones (marine protected areas, navigation routes) and socio-environmental constraints were overlaid to define four progressive suitability levels (theoretical, technical, environmental, and socio-political). To validate mechanical feasibility, blade performance simulations were conducted using ANSYS under local wind loads and atmospheric density conditions. Results identified wind speeds above 6.2 m/s and power density up to 173 W/m², suitable for fixed-bottom offshore turbines. Figure 1 demonstrates the nonlinear correlation between wind velocity and power output, while Figure 2 illustrates turbine response and energy capture efficiency under Salinópolis-specific scenarios. The study reinforces the coastal zone's strategic value for offshore development, emphasizing the need for Marine Spatial Planning (UNESCO, 2011) and hybrid system integration in future deployments. This comprehensive methodology supports replicable assessments in other tropical coastal regions undergoing energy transition.

Keywords: offshore wind energy; Salinópolis; multi-criteria; energy planning; bathymetry

INTRODUCTION

The growing demand for renewable sources in Brazil is driving the exploration of offshore wind resources. With its extensive coastline and consistent winds, the coast of Pará offers potential for wind farms. According to Silva (2019), the application of multicriteria analysis is essential to identify the most promising areas while respecting technical, environmental, and social constraints. According to Musial et al. (2016), wind resource assessment must consider both resource availability and spatial constraints.

METHODOLOGY

The methodology combined climatic, geographic, and socio-environmental data within GIS platforms (QGIS and ArcGIS), using historical series (1991–2021) and datasets from the Global Wind Atlas, CEPEL (2017), and CPRM (2018). Technical criteria (wind speed, depth, port proximity), environmental constraints (protected areas, shipping routes), and socio-economic zones (fishing areas, land use) were incorporated. A multi-criteria analysis was applied using the Analytic Hierarchy Process (AHP), with weightings assigned according to the relative importance of each factor and matrix consistency validation. Four suitability levels were defined: theoretical, technical, environmental, and socio-political, based on progressive exclusions. Mechanical feasibility was tested via ANSYS simulations under local wind loads and regional aerodynamic parameters. This approach enabled the identification of priority offshore wind zones based on scientifically replicable criteria.



RESULTS AND DISCUSSION

Power density in the most favorable areas reaches 173 W/m^2 , with speeds exceeding 6 m/s (DIAS et al., 2021). Figure 1 illustrates the relationship between wind speed and power density for Salinópolis, according to data extracted from the Global Wind Atlas.

Figure 1 - Relationship between wind speed and power density in Salinópolis.

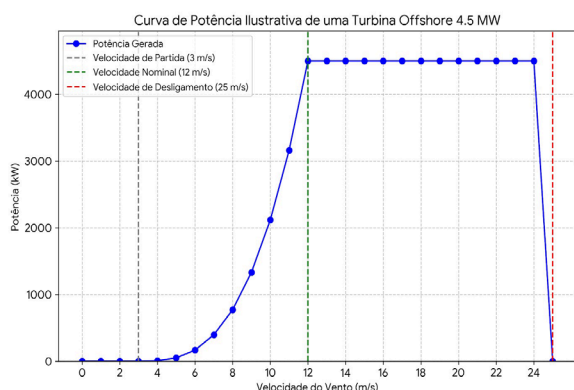
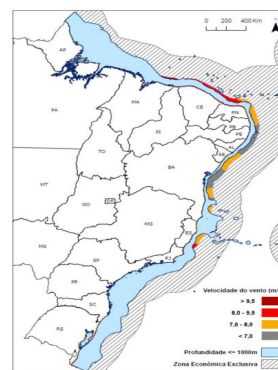


Figure 2 - Overlay of the technical exclusion of depth up to 1000 m on the Theoretical Potential.



Bathymetry indicates a predominance of depths $< 50 \text{ m}$, favorable for turbines with fixed foundations (HUNDLEBY; FREEMAN, 2017). Environmental and socioeconomic conditions point to the need for integrated management through Marine Spatial Planning (UNESCO, 2011). The combination of feasibility factors, including proximity to ports such as Belém, reinforces the region's attractiveness (SILVA, 2019).

CONCLUSIONS

Salinópolis demonstrates significant potential for offshore wind energy, offering promise for future sustainable projects. The application of the multicriteria methodology highlights priority areas, although it depends on infrastructure, local studies, and more accurate data validation. Studies such as those by Alves et al. (2023) reinforce the viability of offshore applications in the energy sector.

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