



Fortaleza, Ceará  
Centro de Eventos do Ceará

## INTERNATIONAL SYMPOSIUM ON ENERGY

Optimizing renewable energy: advanced strategies for enhanced efficiency and sustainability

### POTENCIAL E LIMITAÇÕES DA ENERGIA EÓLICA EM ALTAMIRA-PA: UMA ABORDAGEM SUSTENTÁVEL

#### POTENTIAL AND LIMITATIONS OF WIND ENERGY IN ALTAMIRA, PARÁ: A SUSTAINABLE APPROACH

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#### RESUMO

Este estudo avalia a viabilidade da energia eólica como alternativa sustentável nos municípios do Pará, com foco em Altamira. A partir de revisão bibliográfica, estudo de caso em Salinópolis (RAZEC 266) e simulações no RapidMiner, analisaram-se 66 cenários (2021–2025). Os dados indicam que 78% das velocidades médias de vento são inferiores a 1,0 m/s, com apenas 14% apresentando potencial de geração elevado. Apesar de benefícios socioeconômicos e ambientais, limitações técnicas e impactos ecológicos (ruído e fragmentação florestal) tornam inviável seu uso como fonte primária em Altamira. Recomenda-se uso complementar em microescala, com fontes híbridas e zoneamento rigoroso.

**Palavras-chave:** Energia eólica; Sustentabilidade; Altamira; Potencial eólico; Impactos socioambientais.

#### ABSTRACT

This study evaluates the viability of wind energy as a sustainable alternative in the municipalities of Pará, with a focus on Altamira. Based on a literature review, a case study in Salinópolis (RAZEC 266) and simulations in RapidMiner, 66 scenarios were analyzed (2021–2025). The data indicates that 78% of average wind speeds are below 1.0 m/s, with only 14% showing high generation potential. Despite socioeconomic and environmental benefits, technical limitations and ecological impacts (noise and forest fragmentation) make its use as a primary source in Altamira unfeasible. Complementary use on a microscale is recommended, with hybrid sources and strict zoning.

**Keywords:** Wind energy; Sustainability; Altamira; Wind potential; Socio-environmental impacts.

#### INTRODUCTION

The search for renewable energy sources is intensifying in light of the need to mitigate the environmental impacts of traditional sources. As highlighted by Borges et al. (2015), electricity is a key factor for socioeconomic development and quality of life. In this context, wind energy emerges as a strategic alternative in Pará, but its implementation in municipalities with extensive green areas such as Altamira requires critical analysis of the socio-environmental trade-offs. Although it offers benefits such as clean energy and employment opportunities, studies point to impacts such as ecosystem disturbance and noise (Saber Elétrica, [n.d.]), motivating this research focused on the particularities of Altamira.

#### METHODOLOGY

A mixed approach was adopted, integrating bibliographic research on renewable energy in Pará with a case study in Salinópolis (based on the RAZEC 266 vertical wind turbine). Wind data was analyzed using Hellman's Law and the power equation. In addition, RapidMiner was used with decision trees to simulate scenarios of efficiency and economic viability in Altamira, modeling climatic and technical variables.



## RESULTS AND ANALYSIS

The Altamira data revealed average speeds between 0.4 and 1.6 m/s, with 78% of scenarios below 1.0 m/s and only 14% with high generation ( $\geq 1.2$  m/s). This performance restricts its application to microgeneration systems. Socioeconomically, wind energy can reduce costs and generate employment opportunities in isolated areas, but it requires high investments. Environmentally, the main risks are noise ( $>45$  dB) and forest fragmentation. Therefore, its adoption should consider alternatives with less impact and integration with other renewable sources.

Figure SEQ Figura \\* ARABIC 1 – Decision Trees



Source: Authors

## CONCLUSION

It is concluded that, due to low wind potential between 2021 and 2025, wind energy is not viable as a primary source in Altamira. However, its complementary use may be beneficial in isolated communities, provided it is applied with low-impact technologies, careful zoning, and integration with sources such as solar power and biomass. It is suggested to start with pilot projects in anthropized areas, with community participation and prior environmental assessment.

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