



DO CAJU ÀS EÓLICAS: COMO A GERAÇÃO DE ENERGIA ELÉTRICA EM SERRA DO MEL – RN REFORÇA A INJUSTIÇA ENERGÉTICA?
FROM CASHEW TO WIND POWER: HOW ELECTRICITY GENERATION IN SERRA DO MEL – RN REINFORCES ENERGY INJUSTICE?

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RESUMO

O município de Serra do Mel, no estado do Rio Grande do Norte, tem se destacado no cenário nacional da expansão das fontes eólicas de energia. No entanto, à semelhança do que ocorre em outras regiões do Brasil, emergem relatos de injustiças energéticas que persistem mesmo diante da transição para fontes renováveis. Com base em dados primários disponibilizados pela Agência Nacional de Energia Elétrica (Aneel), este trabalho investiga o destino da eletricidade gerada no município, com o objetivo de identificar a qual ambiente de contratação essa produção está sendo direcionada. Os resultados indicam que a maior parte da energia gerada é destinada ao Ambiente de Contratação Livre (ACL), embora uma parcela menor, se dirija ao Ambiente de Contratação Regulado (ACR). Parte-se do entendimento de que os principais beneficiários da energia renovável no país têm sido os grandes consumidores, os quais, paradoxalmente, pagam tarifas inferiores àquelas cobradas das populações que convivem diretamente com os impactos desses empreendimentos — um cenário que evidencia a reprodução de elementos característicos da injustiça energética.

Palavras-chave: Serra do Mel; fonte eólica; comercialização; injustiça energética.

ABSTRACT

The municipality of Serra do Mel, in the state of Rio Grande do Norte, has stood out on the national stage for the expansion of wind energy sources. However, as in other regions of Brazil, reports of energy injustices have emerged, persisting even amid the transition to renewable sources. Based on primary data provided by the Brazilian Electricity Regulatory Agency (Aneel), this study investigates the destination of the electricity generated in the municipality, aiming to identify which contracting environment this production is being directed to. The results indicate that the majority of the energy generated is allocated to the Free Contracting Environment (ACL), although a smaller portion is directed to the Regulated Contracting Environment (ACR). The analysis is grounded in the understanding that the main beneficiaries of renewable energy in the country have been large consumers, who, paradoxically, pay lower rates than the populations living directly with the impacts of these developments—a scenario that reflects the reproduction of patterns typical of energy injustice.

Keywords: Serra do Mel; wind power; commercialization; energy injustice.



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1 INTRODUCTION

The state of Rio Grande do Norte has stood out nationally for its high potential and significant installed capacity in renewable energy sources (solar photovoltaic and wind), which currently totals 20.431 GW (EPE, 2025a, p. 158). Despite its relatively small territorial size, the intensity and consistency of the winds in various regions of the state contribute significantly to its prominence in the energy sector. Among the municipalities concentrating this development, Serra do Mel stands out, located in the western mesoregion of the state of Rio Grande do Norte. The municipality is home to one of the largest wind farms in the region, as well as centralized photovoltaic plants, positioning it as a strategic territory in the expansion of renewable energies.

The municipality of Serra do Mel covers a territorial area of 620.241 km². According to the 2022 Demographic Census, the local population is 13,091 inhabitants, resulting in a population density of 21.11 inhabitants per km² (IBGE, 2025). The origin of the municipality dates back to the 1970s, as a result of a colonization project initiated in 1972 and completed in 1982, during the government of Cortez Pereira. This project was part of the agrarian reform policy and was based on the principles of cooperativism and agroindustry development, with an emphasis on cashew cultivation (Melo, 2020, p. 32; Jacinto, 2024, p. 95 – 96). The geographical organization of the municipality was structured through the distribution of rural production villages, each named in honor of a Brazilian state. These villages were planned with an average distance of 5 km between them. The organizational model adopted combines collective production with individual land ownership (Jacinto, 2024, p. 96, *apud* Ortega, Nunes e Godeiro, 2004). Currently, the municipality is organized into 22 rural production agro-villages. They are: Vila Rio Grande do Sul, Vila Santa Catarina, Vila Paraná, Vila São Paulo, Vila Guanabara, Vila Rio de Janeiro, Vila Minas Gerais, Vila Goiás, Vila Mato Grosso, Vila Espírito Santo, Vila Brasília, Vila Bahia, Vila Pernambuco, Vila Rio Grande do Norte, Vila Sergipe, Vila Alagoas, Vila Piauí, Vila Ceará, Vila Paraíba, Vila Acre, Vila Maranhão, Vila Pará e Vila Amazonas. The territorial configuration of these villages had as its main objective the development of cashew cultivation, and all the infrastructure implemented was planned to meet the demands of cashew production and processing. The project proposed that each village have approximately 60 plots, with each settler receiving a house accompanied by a plot. All plots consist of 50 hectares, designed to include 15 hectares for permanent cashew cultivation, 10 hectares for temporary crops, and 25 hectares of native forest reserved as a conservation area (Jacinto, 2024, p. 95, *apud* Pereira; Jacinto; Pereira, 2016, p. 123).

This study aims to analyze the case of Serra do Mel in order to identify potential elements of energy injustice arising from the unequal distribution of harms and benefits associated with energy generation (Mendes, Sampaio & Almeida, 2025, p. 2–4), related to the wind power expansion in the municipality, such as access to the energy generated within the territory. In recent years, there have been numerous reports and mobilizations denouncing injustices in the installation of large renewable energy projects, especially in wind power generation, which subject the population to degrading conditions and ultimately shift the burden of the energy transition onto the most vulnerable.

An aspect that deserves deeper understanding is the relationship between energy access and the commercialization of the energy generated in the municipality. Many believe that the installation of a wind turbine will guarantee electricity access to households neighboring the project that may currently lack physical access to the service. Authors such as Lima et al. (2017, p. 6) even relate energy access as a positive impact of wind power expansion. This understanding can only be supported if one considers the increased electricity supply to the power system as a principle; however, this



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does not guarantee, at least within the structure of the Brazilian electricity sector, physical access for families that still require the service. This occurs because the energy generated in centralized generation parks is traded through the Regulated Contracting Environment (ACR, in portuguese) or the Free Contracting Environment (ACL, in portuguese) and dispatched at high voltage to the National Interconnected System (SIN, in portuguese), which is guaranteed by the natural monopoly of the electricity service. While the energy consumed by small electricity consumers is supplied through the local distributor—typically a state-level concessionaire—which purchases energy generated by wind and other sources via auctions conducted by the Electricity Trading Chamber (CCEE, in portuguese), this energy is distributed at medium voltage and then transformed into low voltage for final consumption. The distributors are also responsible for the physical universalization of the electricity service in the country, both within the area served by the SIN and in isolated systems.

It is noteworthy that the local population has led a movement contesting the expansion of wind energy projects, highlighting the lack of significant benefits for the community. In this context, the first lawsuit filed by residents against a wind energy company in Brazil—the French multinational Voltalia—took place, revealing social tensions and conflicts arising from the implementation of these projects.

In this context, the municipality, whose main economic activity was cashew cultivation, began to share its physical and economic landscape with the expansion of wind energy. In addition to the new infrastructures required for the implementation of the wind farms—such as the installation of wind turbines, road construction, and deforestation of cashew orchards—projects aimed at transmitting the generated energy were also built, including transmission lines and substations (Jacinto, 2024, p. 97).

This new reality caused divisions within the community, as observed during the public hearing held on July 11, 2025, convened by the Human Rights Commission of the Legislative Assembly of Rio Grande do Norte. On that occasion, both supporters of the energy generation expansion, and critics, who point to the negative impacts resulting from this process, expressed their views. Finally, through the applied methodology, it will be possible to observe the destination of the electricity generated in Serra do Mel, at least in terms of the market it is directed to, thereby enhancing the debate surrounding Brazil's energy transition—that is, to whom and to what it has been most beneficial: to reduce social inequalities, including poverty and energy injustice, or to perpetuate the existing energy model?

2 METHODOLOGY

The methodology framework adopted to understand the commercialization dynamics of the energy generated by the wind farms in Serra do Mel was based on primary data derived from the results of generation auctions conducted within the Regulated Contracting Environment, organized by the National Electric Energy Agency (Aneel, in portuguese). The analysis of these data allowed for the identification of both the amount of physical energy contracted by each wind farm and the volume effectively traded within this regulated environment.

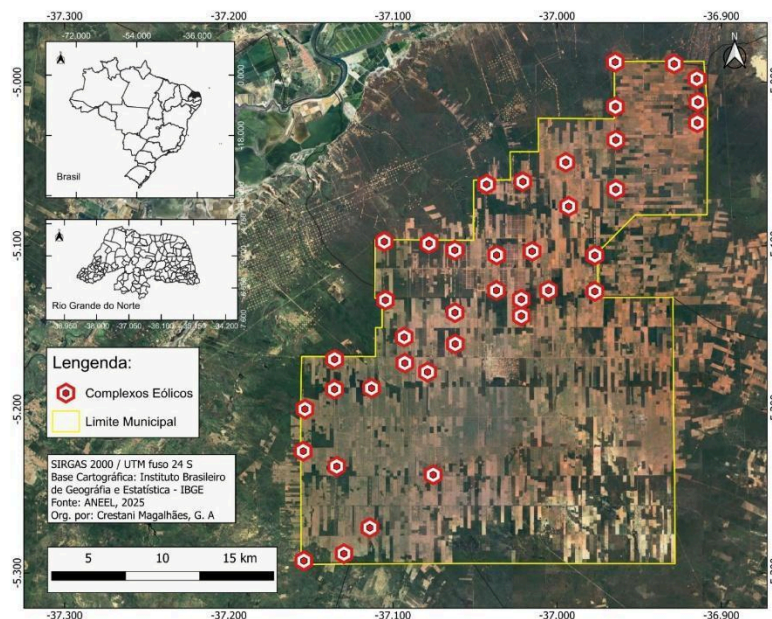


Based on this information, it is possible to infer that the portion of physical energy not traded through auctions promoted by the Electric Energy Trading Chamber (CCEE, in portuguese) is presumably destined for the Free Contracting Environment, the absence of certain wind farms in Aneel's auction records indicates that all the energy generated by them is directed to the ACL.

3 RESULTS AND DISCUSSIONS

Since the commissioning of the first wind farm in the municipality of Serra do Mel in December 2015, the region has been consolidating as a significant hub for wind energy generation, with wind turbines distributed across several of its villages, as illustrated in Figure 1. Although the city was originally conceived as a model of agrarian reform focused on agricultural production, the electricity currently generated in the territory plays a significant role in meeting national demand by being integrated into the National Interconnected System.

Figure 1 - Wind Complexes in Operation, Under Construction, and Planned in the Municipality of Serra do Mel - RN



Fonte: Autoria própria, com adoção de dados da Aneel (2025c)

According to data from the National Electric Energy Agency (Aneel), in 2025 the municipality of Serra do Mel had 36 wind farms in operation, totaling 360 wind turbines. Additionally, three other projects had already been granted permits, which are expected to add 21 more wind turbines, although construction has not yet begun (ANEEL, 2025). The total granted capacity of the 39 wind farms corresponds to approximately 1.2 gigawatts (GW), while the installed capacity already in operation reaches about 1.26 GW (ibid.).

Table 1 presents, based on data from Aneel (2025), the 36 wind farms currently in operation in the municipality of Serra do Mel, including their respective granted capacities, the number of wind turbines per farm, the installed capacity per unit, and the



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commissioning date of each complex. Additionally, Table 2, based on data from Aneel (2025), lists the three projects already granted permits by Aneel — Vila Alagoas I, V, and VI — which, despite being authorized, have not yet commenced construction.

Tabela 1 - Wind power plants in operation in 2025 in the municipality of Serra do Mel – RN

Project name (Aneel)	Granted Capacity (kW)	Number of turbines and installed capacity	Operation start date
<i>Caiçara I</i>	27000	9 generation units of 3.000 kW	05/12/2015
<i>Caicára II</i>	18000	6 generation units of 3.000 kW	09/12/2015
<i>Junco I</i>	24000	8 generation units of 3.000 kW	05/12/2015
<i>Junco II</i>	24000	8 generation units of 3.000 kW	05/12/2015
<i>Potiguar B31</i>	45045	18 generation units of 3.460 kW	20/04/2021
<i>Potiguar B32</i>	48510	9 generation units of 4.200 kW	12/05/2021
<i>Potiguar B33</i>	58905	10 generation units of 4.200 kW	02/06/2021
<i>Ventos de Vila Acre II</i>	31185	13 generation units of 2.100 kW	24/12/2019
<i>Ventos de Vila Ceará I (antiga Vila Paraíba I)</i>	31185	16 generation units of 2.000 kW	28/5/2020
<i>Ventos de Vila Ceará II</i>	31185	16 generation units of 2.000 kW	08/02/2020
<i>Ventos de Vila Mato Grosso I (antiga Vila Alagoas III)</i>	58905	5 generation units of 4.200 kW	11/06/2021
<i>Ventos de Vila Paraíba I (antiga Vila Paraíba III)</i>	34650	16 generation units of 2.000 kW	28/05/2020
<i>Vila Acre I</i>	27300	12 generation units of 2.100 kW	23/06/2017
<i>Vila Alagoas II</i>	21000	7 generation units of 4.200 kW	18/02/2022
<i>Vila Amazonas V</i>	24000	10 generation units of 3.000 kW	27/08/2016
<i>Vila Ceará I</i>	31950	11 generation units of 2.000 kW	04/03/2020
<i>Vila Espírito Santo I (antiga Potiguar B21)</i>	33600	11 generation units of 4.200 kW	26/11/2021
<i>Vila Espírito Santo II (antiga Potiguar B22)</i>	37800	9 generation units of 4.200 kW	18/02/2022
<i>Vila Espírito Santo III (antiga Potiguar B23)</i>	37800	11 generation units of 4.200 kW	11/01/2022
<i>Vila Espírito Santo IV (antiga Potiguar B24)</i>	37800	7 generation units of 4.200 kW	25/02/2022
<i>Vila Espírito Santo V (antiga Potiguar B25)</i>	37800	10 generation units of 4.200 kW	31/12/2021
<i>Vila Maranhão I</i>	31950	9 generation units of 3.465 kW	11/02/2021
<i>Vila Maranhão II</i>	31950	9 generation units of 3.465 kW	31/03/2021
<i>Vila Maranhão III</i>	31950	9 generation units of 3.465 kW	29/09/2020
<i>Vila Pará I</i>	27000	10 generation units of 3.000 kW	10/09/2016
<i>Vila Pará II</i>	24000	10 generation units of 3.000 kW	15/09/2016
<i>Vila Pará III</i>	24000	10 generation units of 3.000 kW	07/10/2016



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<i>Vila Piauí I</i>	37800	9 generation units of 4.200 kW	17/07/2020
<i>Vila Piauí II</i>	37800	9 generation units of 4.200 kW	27/08/2020
<i>Vila Piauí III</i>	42000	10 generation units of 4.200 kW	08/07/2020
<i>Vila Rio Grande do Norte I</i>	25200	6 generation units of 4.200 kW	25/03/2020
<i>Vila Rio Grande do Norte II</i>	37800	9 generation units of 4.200 kW	18/04/2020
<i>Vila Sergipe I</i>	37800	9 generation units of 4.200 kW	27/05/2020
<i>Vila Sergipe II</i>	37800	9 generation units of 4.200 kW	30/05/2020
<i>Vila Sergipe III</i>	16800	4 generation units of 4.200 kW	09/06/2020
<i>Vila Paraíba II</i>	34650	16 generation units of 2.000 kW	10/04/2020

Table 2 - Granted but Not Yet Started Wind Power Projects in the Municipality of Serra do Mel - RN (May 2025)

Project name (Aneel)	Granted Capacity (kW)	Number of turbines and installed capacity
<i>Vila Alagoas VI</i>	25200	6 generation units of 4.200 kW
<i>Vila Alagoas I</i>	21000	5 generation units of 4.200 kW
<i>Vila Alagoas V</i>	42000	10 generation units of 4.200 kW

Table 3 presents detailed information (name, physical guarantee, sales in the Regulated Contracting Environment, percentage sold, and auction date in the ACR) for the wind farms that have had at least a portion of their energy contracted through the ACR, according to data from Aneel (2025b).

Table 3 - Wind Farms in Serra do Mel with Electricity Sold in the Regulated Contracting Environment (ACR) (May 2025)

Project name (Aneel)	Physical Guarantee (MWm)	Sold ACR (MWm)	Percentage Sold in ACR (%)	Auction
<i>Ventos de Vila Mato Grosso I (antiga Vila Alagoas III)</i>	11,00	3,3	30,00	2019/3
<i>Vila Maranhão III</i>	16,8	8,2	48,81	2018/3
<i>Ventos de Vila Paraíba I (antiga Vila Paraíba III)</i>	18,8	17,9	95,21	2017/4
<i>Ventos de Vila Ceará II</i>	18,8	15,4	81,91	2017/5
<i>Caiçara I</i>	14,6	13,5	92,47	2011/7
<i>Caicára II</i>	9,6	9,3	96,88	2011/7
<i>Junco I</i>	13,1	12,1	92,37	2011/7
<i>Junco II</i>	13,3	11,4	85,71	2011/7
<i>Vila Amazonas V</i>	14,8	10,5	70,95	2013/10
<i>Vila Pará I</i>	14,2	11,8	83,10	2013/10
<i>Vila Pará II</i>	14	10,6	75,71	2013/10



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<i>Vila Pará III</i>	13,9	10,5	75,54	2013/10
<i>Vila Maranhão I</i>	15,7	8,3	52,87	2018/3
<i>Vila Maranhão II</i>	15,4	8,3	53,90	2018/3
<i>Vila Acre I</i>	15,2	14,4	94,74	2015/9
<i>Ventos de Vila Acre II</i>	16,6	15,5	93,37	2017/5
<i>Vila Ceará I</i>	13,4	8,2	61,19	2018/3
<i>Vila Paraíba II</i>	19,2	17,7	92,19	2017/4
<i>Ventos de Vila Paraíba I (antiga Vila Paraíba III)</i>	19,9	15,8	79,4	2017/5

Based on the analysis of Table 3, it is observed that among the wind farms in Serra do Mel with energy sold in the Regulated Contracting Environment (ACR), out of the 288.3 average megawatts (MWm) of physical guarantee, 222.7 MWm are allocated to the ACR, corresponding to 77.25%. Meanwhile, the remaining 65.6 MWm, equivalent to 22.75%, are being directed to the Free Contracting Environment (ACL).

Additionally, it is observed that out of the 36 wind farms currently in operation, only 19 have participated in any new energy auction promoted by Aneel. The remaining portion, consisting of the 17 other wind farms — Potiguar B31, Potiguar B32, Potiguar B33, Vila Alagoas II, Vila Espírito Santo I, II, III, IV e V, Vila Piauí I, II e III, Vila Rio Grande do Norte I e II, e Vila Sergipe I, II e III — Their energy was not commercialized through the Electric Energy Trading Chamber and, therefore, all of the electricity they generate is directed to the Free Contracting Environment. These wind farms have a combined operational capacity of 646.08 MW, representing 54.93% of the total installed capacity of 1,176 MW in the Serra do Mel wind complex.

When also accounting for the share of energy from wind farms that participated in auctions but allocate part of their production (22.75%) to the Free Contracting Environment, it is estimated that a total of 766.66 MW — equivalent to 65.16% of the energy generated in the municipality — is being traded in the ACL.

In 2025, according to MegaWhat (2025), the average price of electricity traded in the Free Contracting Environment was R\$ 150 per megawatt-hour (MWh). In contrast, the average cost of energy and capacity traded by distribution agents in the Regulated Contracting Environment during the same period was R\$ 307.29 per megawatt-hour (MWh) (Brazil, 2024b). This situation highlights a significant disparity: the residents of Serra do Mel, despite living daily alongside hundreds of wind turbines installed in their territory, end up paying more than twice as much for electricity access compared to those who, integrated into the Free Contracting Environment, consume most of the energy generated locally.

4 CONCLUSIONS

The energy transition, especially marked by the expansion of wind power, has significantly transformed the economic and social landscape of the municipality of Serra do Mel, in the state of Rio Grande do Norte. Over the past two decades, hundreds of wind turbines have been installed in the region, sparking debates about the benefits and negative impacts of this energy phenomenon in the territory. To deepen these discussions, this study analyzed primary data from the Brazilian Electricity Regulatory Agency (Aneel) with the aim of identifying the destination of the electricity generated by the 36 wind farms



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currently operating in Serra do Mel. The data reveal that, predominantly, this energy is directed to the Free Contracting Environment, where it is consumed by large consumers across the country, to the detriment of small consumers—such as all residents of the municipality—who remain in the Regulated Contracting Environment and end up paying proportionally much higher electricity prices. This finding contributes to the debate on the true purposes of the energy transition in Brazil, questioning whether it has indeed promoted the eradication of poverty and energy injustice.

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