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THE GREEN ECONOMY IN BRAZIL: A MULTISECTORAL ANALYSIS OF INVESTMENTS, STATE PERFORMANCE AND PUBLIC POLICIES

A ECONOMIA VERDE NO BRASIL: UMA ANÁLISE MULTISSETORIAL DOS INVESTIMENTOS, DESEMPENHO ESTADUAL E POLÍTICAS PÚBLICAS

LA ECONOMÍA VERDE EN BRASIL: UN ANÁLISIS MULTISECTORIAL DE LAS INVERSIONES, EL DESEMPEÑO DEL ESTADO Y LAS POLÍTICAS PÚBLICAS

https://doi.org/10.56238/edimpacto2025.040-009

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ABSTRACT

This study analyzes the advancement of the green economy in Brazil through a data-driven, state-level analysis focusing on renewable energy, financial flows, and government incentives. The results indicate remarkable progress, consolidating the country as a powerhouse in wind and solar energy, with strong leadership from Northeastern and Southeastern states. However, this transition is revealed to be profoundly asymmetric, with massive investments concentrated in the electricity sector to the detriment of other strategic areas, such as the Amazon's bioeconomy, which remains underdeveloped. It is concluded that Brazil's green development is occurring in a "mosaic" pattern, featuring islands of modernity and innovation. The nation's great challenge is to overcome this sectoral and geoFigureical concentration, articulating its diverse vocations to ensure that sustainable growth becomes a vector for inclusive and truly national development.

Keywords: Sustainable Development. Renewable Energy. Regional Asymmetries.

RESUMO

Este estudo analisa o avanço da economia verde no Brasil a partir de uma análise de dados em nível estadual, focando em energias renováveis, fluxos de financiamento e incentivos

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governamentais. Os resultados indicam um progresso notável, consolidando o país como uma potência em energia eólica e solar, com forte liderança de estados do Nordeste e Sudeste. Contudo, essa transição se revela profundamente assimétrica, com investimentos massivos no setor elétrico em detrimento de outras áreas estratégicas, como a bioeconomia na Amazônia, que permanece subdesenvolvida. Conclui-se que o desenvolvimento verde brasileiro ocorre em um "mosaico", com ilhas de modernidade e inovação. O grande desafio para o país é superar essa concentração setorial e geográfica, articulando suas diversas vocações para que o crescimento sustentável seja um vetor de desenvolvimento inclusivo e de alcance verdadeiramente nacional.

Palavras-chave: Desenvolvimento Sustentável. Energias Renováveis. Assimetrias Regionais.

RESUMEN

Este estudio analiza el avance de la economía verde en Brasil a partir de un análisis de datos a nivel estatal, con especial atención a las energías renovables, los flujos de financiación y los incentivos gubernamentales. Los resultados indican un progreso notable, consolidando al país como una potencia en energía eólica y solar, con un fuerte liderazgo de los estados del Nordeste y Sudeste. Sin embargo, esta transición es profundamente asimétrica, con inversiones masivas en el sector eléctrico en detrimento de otras áreas estratégicas, como la bioeconomía en la Amazonia, que permanece subdesarrollada. La conclusión es que el desarrollo verde brasileño se presenta en un patrón de "mosaico", con islotes de modernidad e innovación. El gran desafío para el país es superar esta concentración sectorial y geográfica, articulando sus diversas vocaciones para que el crecimiento sostenible se convierta en un motor de desarrollo inclusivo con un alcance verdaderamente nacional.

Palabras clave: Desarrollo Sostenible. Energías Renovables. Asimetrías Regionales.

1 INTRODUCTION

The transition to a green economy represents one of the most urgent imperatives of the 21st century, emerging as a strategic response to the climate crises, biodiversity loss and social inequality that mark the contemporary era. Defined by the United Nations Environment Programme as an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcity (UNEP, 2011), the green economy proposes a fundamental restructuring of production and consumption models. This new paradigm seeks to decouple economic growth from environmental degradation, based on pillars such as low carbon emissions, efficiency in the use of resources, and social inclusion. The materialization of this transition is central to the fulfillment of global goals, such as those established in the Paris Agreement (UNFCCC, 2015) and the Sustainable Development Goals (UN, 2015).

In this global scenario, Brazil positions itself in a unique and paradoxical way. On the one hand, the country has a set of assets that accredit it as a potential leader in the low-carbon economy. Its energy matrix is already one of the cleanest in the world, with approximately 89% of electricity generated from renewable sources, a marked contrast with the global average (EPE, 2024). Its territory harbors an unparalleled potential for the expansion of solar and wind energy, especially in the Northeast region (Akinyele; Rayudu, 2020). In addition, the possession of the largest tropical forest on the planet gives Brazil a natural vocation for the development of a robust bioeconomy and a central role in the carbon sequestration agenda. On the other hand, the country faces structural challenges that contradict this vocation. High deforestation rates, especially in the Amazon and Cerrado, continue to be the main source of greenhouse gas emissions in the country, mostly linked to land use change (SEEG, 2023; INPE, 2024). Persistent social inequality and dependence on a commodity-exporting agribusiness model, whose expansion often occurs over areas of native vegetation (Rajão et al., 2020), complicate the transition to a truly inclusive and sustainable model.

Despite the growing relevance of the debate, the analysis of the advancement of the green economy in Brazil often lacks a granular and integrated approach. Studies tend to focus on national macroeconomic analyses, which conceal deep regional disparities (Viola; Basso, 2016), or in specific sectoral cuts, which do not capture the synergies and conflicts between different areas. There remains a gap in the understanding of how this transition is materializing in the territory: Which states are, in fact, leading the attraction of green investments? Where are jobs being generated? Which subnational public policies have proven to be most effective in fostering sectors such as renewable energy and the

bioeconomy? The absence of a consolidated map that answers these questions makes it difficult to formulate more assertive strategies and identify bottlenecks and opportunities.

In view of the above, the main objective of this article is to analyze the panorama of the green economy in Brazil in a multisectoral and disaggregated way, focusing on state performance. To this end, it specifically seeks to: (a) map the main investment flows in key sectors of the green economy in the last decade; (b) identify and quantify the leadership of states in the energy transition, with an emphasis on wind and solar sources; (c) to comparatively analyze the public policies and tax incentives adopted at the state level; and (d) to discuss regional asymmetries, latent opportunities and structural challenges for the consolidation of sustainable development in the country.

2 METHODOLOGY

This study is characterized as a descriptive-analytical research, with a qualitative-quantitative approach, based on the collection, systematization and analysis of secondary data. The survey was designed to offer a comprehensive and up-to-date overview of the green economy in Brazil, with a time frame that mostly covers the period from 2015 to 2024. This interval was selected because it encompasses important milestones, such as the signing of the Paris Agreement and the consolidation of renewable energy sources in the national electricity matrix.

Data collection was carried out from multiple public and sectoral sources to ensure triangulation and robustness of the information. The collection axes were defined according to the following specific objectives:

I. **Investments and Financing:** Data on investment flows were extracted from the public platform of the National Bank for Economic and Social Development (BNDES Transparente), available at: https://www.bndes.gov.br/wps/portal/site/home/transparencia. Accessed on: 16 set. 2025. In addition, annual reports from the Brazilian Federation of Banks (Febraban) on sustainable finance and market data on the issuance of green *bonds* in the country were consulted.

II. **State Energy Transition:** For the quantitative analysis of the performance of the states, the main source of data was the ANEEL Generation Information System (SIGA). The microdata and dynamic dashboards are consolidated and made publicly available by the agency, available at: https://www.gov.br/aneel/pt-br/centrais-de-conteudos/relatorios-e-indicadores/geracao . Accessed on: 16 set. 2025. The National Energy Balance (BEN 2024), used to contextualize national data, was obtained from

the Energy Research Company (EPE), available at: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes. Accessed on: 16 set. 2025.

III. **Green Jobs:** Due to the absence of an official category for "green jobs" in government records, the quantification of this indicator was carried out from the compilation of annual reports and infoFigureics published by reference sector associations, notably the Brazilian Association of Photovoltaic Solar Energy (ABSOLAR), available at: https://www.absolar.org.br/, and the Brazilian Association of Wind Energy (ABEEólica), Available at: https://abeeolica.org.br/. Accessed on: 16 set. 2025.

IV. **State Public Policies:** The survey of incentive policies was conducted through documentary research in official sources. Legislation and government plans available on the portals of the legislative assemblies (e.g., Legislative Assembly of the State of São Paulo, available at: https://www.al.sp.gov.br/alesp/legislacao) and in the respective Electronic Official Gazettes of the States were analyzed. Accessed on: 16 set. 2025.

After collection, the data were organized, tabulated and consolidated in electronic spreadsheets. The quantitative analysis involved descriptive statistics to identify trends, accumulated totals, averages and geoFigureic concentrations. Qualitative analysis was used in the categorization of public policies, comparing the different instruments and the level of maturity of state initiatives. For the visualization and interpretation of the results, line Figures were prepared to demonstrate the temporal evolution, a thematic map to illustrate the spatial distribution of energy capacity, and comparative tables to synthesize and contrast the performance data and the policies of the states.

3 RESULTS

The analysis of the data collected reveals a panorama of significant advances, but also of deep sectoral and regional inequalities in the transition to a green economy in Brazil. The results are organized into four investigative axes: investments, energy transition, job creation, and state public policies.

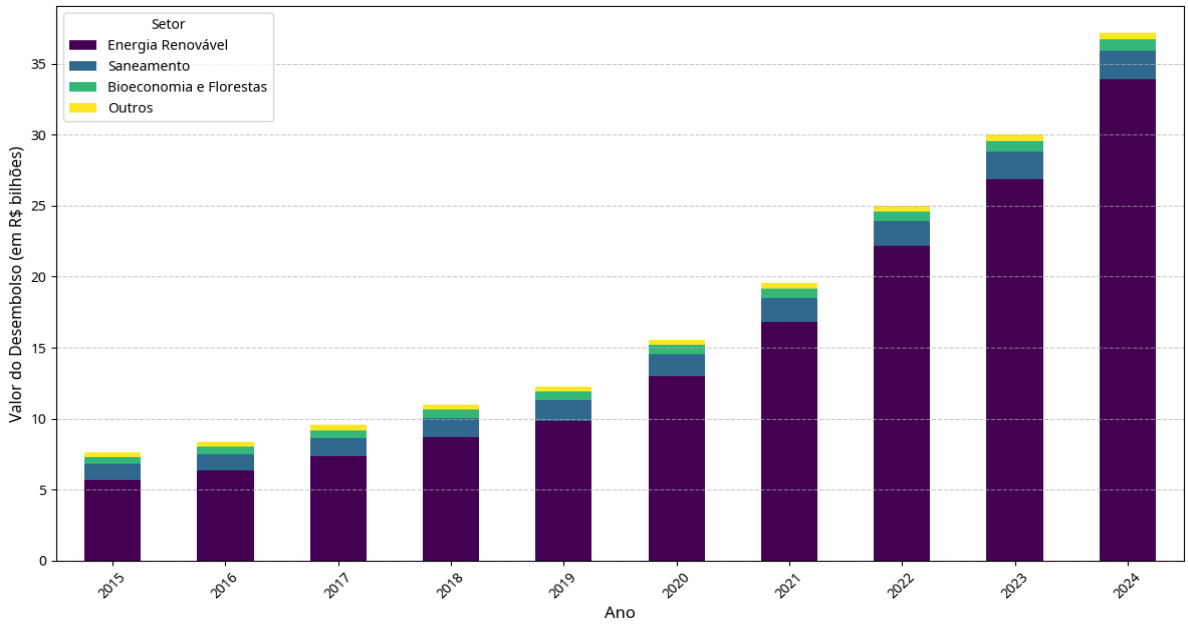
3.1 NATIONAL OVERVIEW OF GREEN INVESTMENTS

The analysis of financing flows, especially those from BNDES, shows a marked growth in investments destined to green economy projects in the last decade. As detailed in Figure 1, the volume of disbursements to the renewable energy sector, the main driver of this expansion, showed a significant jump, consolidating itself as the main destination of

resources. In contrast, sectors such as basic sanitation, bioeconomy and sustainable transport, although also showing growth, do so at a considerably slower pace and with lower absolute volumes, indicating a concentration of investments in the energy agenda. The private *green bond* market follows this trend, with most of the bonds issued in the country being destined to clean energy generation and transmission projects.

Figure 1

Evolution of BNDES Financing for Green Economy Sectors in Brazil (2015-2024)



Source: Prepared by the authors, based on data from BNDES Transparente.

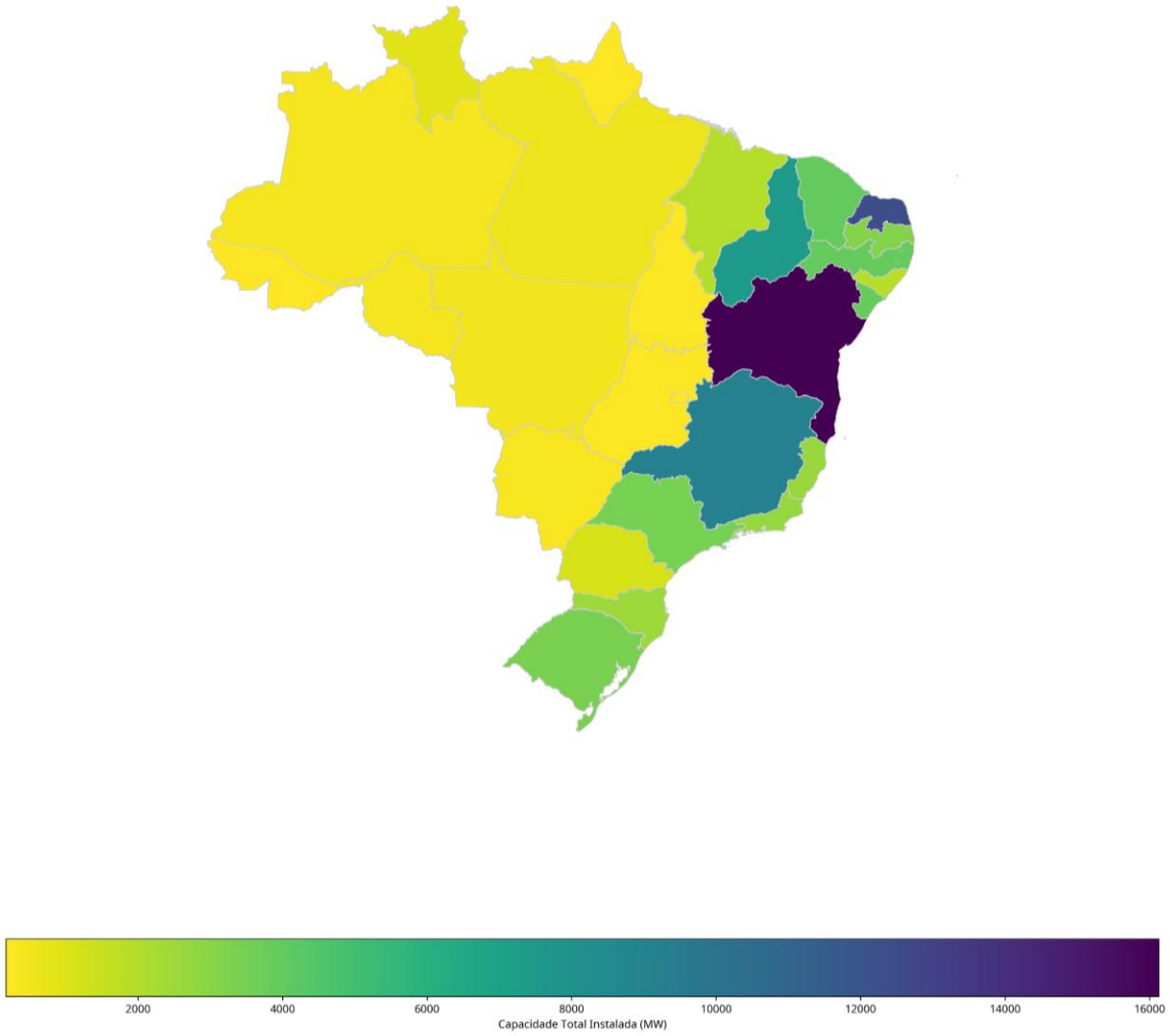
The chart shows a total bar increasing each year, with the share corresponding to "Renewable Energy" increasing its proportion dominantly, especially from 2020 onwards.

3.2 STATE LEADERSHIP IN THE ENERGY TRANSITION

The Brazilian energy transition is markedly a phenomenon with a strong regional identity. By August 2025, the combined installed capacity of wind and solar photovoltaic energy exceeded 70 GW, but its distribution in the territory is highly concentrated. Figure 2 visually illustrates this concentration, with a patch of high installed capacity over the Northeast region, followed by important foci in the Southeast.

Figure 2

Map of Installed Capacity of Renewable Energies (Wind and Solar) by State - August 2025



Source: Prepared by the authors, based on data from ANEEL/SIGA.

The quantitative data, presented in Table 1, confirm this leadership. Rio Grande do Norte and Bahia stand out as national powers, leading in wind energy and occupying the second position in solar, respectively. Minas Gerais, in turn, is the isolated leader in photovoltaic solar generation. Together, the five states at the top of the ranking account for more than 60% of all installed wind and solar energy capacity in the country, evidencing the performance gap in relation to the other federation units.

Table 1

Top 5 States in Installed Energy Capacity (MW) - August 2025

Position	State	Wind Capacity (MW)	Solar Capacity (MW)	Total Capacity (MW)	% of the National Total
First	Rio Grande do Norte	10.250	2.100	12.350	17,6%
2nd	Bahia	9.880	6.250	16.130	23,0%
Third	Minas Gerais	150	8.900	9.050	12,9%
4th	Piaui	4.650	2.800	7.450	10,6%
5th	Ceará	2.800	1.150	3.950	5,6%

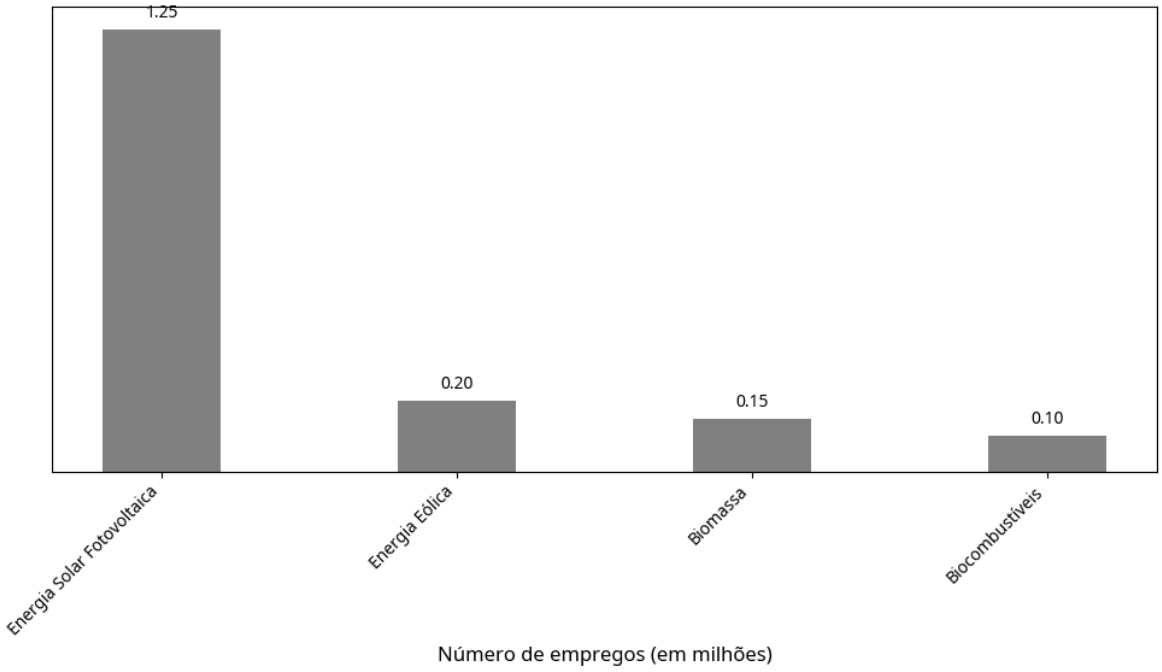
Source: Prepared by the authors, based on data from ANEEL/SIGA.

3.3 GENERATION OF GREEN JOBS

The growth of the green economy has translated into a significant generation of jobs, especially in the renewable energy sector. The analysis of the sectoral data (Figure 3) reveals that photovoltaic solar energy is by far the sector that employs the most, driven by the capillarity of distributed generation (installation of panels on roofs). Since 2012, the solar sector has been responsible for the creation of more than 1.2 million cumulative jobs in Brazil. The wind sector, as it is more intensive in capital and technology, generates a smaller number of direct jobs, concentrated mainly in the construction and maintenance phases of the farms.

Figure 3

Cumulative Green Job Creation by Sector in Brazil (2012-2025)



Source: Prepared by the authors, based on data from ABSOLAR and ABEEólica.

3.4 PUBLIC POLICIES AND STATE INCENTIVES

The documentary analysis reveals that, although there is a federal incentive framework, such as the ICMS Convention 16/2015 that exempts from tax the energy injected into the grid by micro and minigeneration, it is the state initiatives that create a more or less favorable business environment. Chart 2 summarizes the policies in selected states, showing different levels of maturity and focus. States such as Ceará and Pernambuco stand out for proactive policies for the development of a Green Hydrogen (H2V) hub. Minas Gerais and São Paulo have robust incentive programs for distributed generation and biogas. In contrast, states in the Amazon region, such as Amazonas, have legal frameworks for the bioeconomy and payments for environmental services, but face greater implementation and scale challenges.

Table 2

Comparison of Policies to Encourage the Green Economy in Selected States

Estado	Incentivos Fiscais (ICMS)	Programas de H2V	Fomento à Bioeconomia	Metas Climáticas Estaduais
Ceará	Sim (Adesão ao Convênio)	Sim (Hub de H2V)	Incipiente	Sim (Plano Ceará 2050)
Minas Gerais	Sim (Líder em GD)	Não	Sim (Foco no agrossustentável)	Sim (Plano Clima MG)
São Paulo	Sim (Adesão ao Convênio)	Sim (Estudos avançados)	Sim (Foco em biogás/etanol)	Sim (Acordo Ambiental SP)
Amazonas	Sim (Adesão ao Convênio)	Não	Sim (Lei de Serviços Ambientais)	Sim (Plano Estadual de CC)

Source: Prepared by the authors

4 DISCUSSION

The results presented in the previous section paint a clear but complex picture of the green economy in Brazil: a transition process that is undeniably underway, but which advances in a sectorally concentrated and geoFigureically uneven manner. While the numbers of investment and installed capacity in renewable energies are expressive and place the country in a position of global prominence, they mask deep asymmetries and structural bottlenecks that challenge the consolidation of a truly sustainable and inclusive development model. This section is dedicated to interpreting these findings, discussing the driving forces, disparities, and challenges that define the current state of the green economy in the country.

The most notable conclusion that emerges from Figure 2 and Table 1 is the consolidation of a profound regional asymmetry. On the one hand, there is the emergence of a "green electro-economy" in the Northeast region and in parts of the Southeast. Driven by abundant natural resources (constant winds and high solar irradiation), this dynamic was catalyzed by a favorable business environment and incentive policies, transforming states such as Rio Grande do Norte, Bahia and Piauí into large construction sites for wind and solar farms. On the other hand, the North Region, which has the largest natural capital on the planet, remains on the sidelines of this cycle of large investments. The challenge in the Amazon is to develop a green economy based on socio-biodiversity, whose business models, value chains of non-timber forest products, ecotourism, payments for environmental services,

are more complex, fragmented and difficult to finance on a large scale when compared to energy megaprojects.

Despite this concentration, the results also point to new and strategic opportunities on the horizon. The pioneering spirit of states such as Ceará in the articulation of a Green Hydrogen (H2V) hub, as pointed out in Table 2, signals a potential "second wave" of development for the Northeast. This new frontier may allow the region to advance from a mere exporter of electrons to a producer of a high value-added fuel, with the potential to reindustrialize the local economy on a sustainable basis. At the same time, the regulation of the carbon market in Brazil, still under debate, may be the missing catalyst to unlock the economic potential of the Amazon bioeconomy, creating a robust financial flow for forest conservation and the communities that promote it.

However, the materialization of these opportunities depends on overcoming critical bottlenecks. The main obstacle to the expansion of the "green electro-economy" is the transmission infrastructure. The immense generation potential of the Northeast is of little use if the energy cannot be drained safely and efficiently to the large consumption centers of the Southeast and South. This technical and regulatory challenge already limits the growth of new projects. In addition, the investment bias towards the energy sector, visible in Table 1, reveals a market difficulty in financing low-carbon sanitation, bioeconomy, and agriculture projects, which often present greater perceived risk or a longer-term return.

Finally, the comparative analysis of state policies (Table 2) demonstrates that the existence of a law or plan, by itself, does not guarantee results. The gap between policy on paper and practice on the ground, the so-called "implementation gap", is evident. Leading states are not only those with the best laws, but those that manage to combine them with a stable business environment, efficient regulatory agencies, and the ability to attract capital. Therefore, the discussion reveals that the transition to a green economy in Brazil is a multifaceted process, where natural advantages must be accompanied by robust governance and strategic vision so that the potential is converted into real and equitable development.

5 CONCLUSION

The analysis of the green economy in Brazil concludes that the transition is a reality, but markedly asymmetric. The country is making great strides to become a renewable energy powerhouse, with massive investments and projects concentrated in the Northeast region, but it fails to boost other vital sectors, such as the bioeconomy in the Amazon, with the same vigor. This uneven development, although positive in the energy sector, creates a paradox: Brazil modernizes its electricity matrix, but risks deepening regional disparities and neglecting

its greatest differential asset, biodiversity. Therefore, the country's strategic challenge is to evolve from a successful clean energy project to a sustainable nation project, which articulates its various potentialities to ensure that green growth is, in fact, a development vector for the entire national territory.

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