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ELECTRICITY PRICES, STATE POLICIES, AND CORPORATE STRATEGIES IN BRAZIL: A LITERATURE REVIEW USING PROKNOW-C

PREÇO DA ENERGIA ELÉTRICA, POLÍTICAS ESTATAIS E ESTRATÉGIAS EMPRESARIAIS NO BRASIL: UMA REVISÃO DE LITERATURA USANDO O PROKNOW-C

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ABSTRACT: The Brazilian electricity sector is undergoing profound transformations driven by decarbonization and regulatory dynamism. This study conducts a systematic literature review on the interaction between electricity prices, state policies, and corporate strategies in Brazil (2020-2025). The application of the ProKnow-C method in the Periódicos Capes database resulted in a portfolio of 10 high-impact articles, highlighting a recent and concentrated scientific production. The analysis reveals critical structural tensions: the gap between the country's geopolitical leadership and the inertia of implementation due to infrastructure and financing gaps; and corporate behavior under regulatory uncertainty, in which ESG investments and self-generation operate as security mechanisms against the volatility of the Settlement Price for Differences (PLD). A fragmented academic landscape is identified, with a lack of holistic research on wind and hydroelectric sources, despite their dominance in the energy matrix, and limited exploration of disruptive technologies such as smart grids and energy storage. It is concluded that the energy price acts as a thermometer of regulatory friction, reflecting state inefficiencies that shape reactive business behaviors. The study provides an overview for aligning long-term policies and resilient strategies, aiming to overcome the fragmentation between academia and the market.

KEYWORDS: Electricity Price; Energy Policy; Business Strategy; Proknow-C; Brazilian Electricity Sector.

RESUMO: O setor elétrico brasileiro atravessa transformações profundas impulsionadas pela descarbonização e pelo dinamismo regulatório. Este estudo realiza uma revisão sistemática da literatura sobre a interação entre preços da energia elétrica, políticas estatais e estratégias empresariais no Brasil (2020-2025). A aplicação do método ProKnow-C na base Periódicos Capes resultou em um portfólio de 10 artigos de alto impacto, evidenciando uma produção recente e concentrada. A análise revela tensões estruturais críticas: o hiato entre o protagonismo geopolítico do país e a inércia de implementação devido a lacunas de infraestrutura e financiamento; e o

comportamento corporativo sob incerteza regulatória, no qual investimentos em ESG e autoprodução operam como mecanismos de segurança contra a volatilidade do Preço de Liquidação de Diferenças (PLD). Identifica-se um panorama acadêmico fragmentado em nichos, com escassez de pesquisas holísticas sobre as fontes eólica e hidrelétrica, apesar de sua dominância na matriz, e exploração limitada de tecnologias disruptivas como smart grids e armazenamento de energia. Conclui-se que o preço da energia atua como um termômetro de fricção regulatória, refletindo ineficiências estatais que moldam comportamentos empresariais reativos. O estudo oferece um panorama para o alinhamento de políticas de longo prazo e estratégias resilientes, visando superar a fragmentação entre a academia e o mercado.

PALAVRAS CHAVE: Preço da Energia Elétrica; Política Energética; Estratégia Empresarial; Proknow-C; Setor Elétrico Brasileiro.

1. INTRODUCTION

The Brazilian electricity sector is undergoing a profound transformation, driven by growing demand, the diversification of the energy matrix, global decarbonization pressures, and a constantly evolving regulatory and market environment. In this dynamic context, the interaction between electricity prices (regulated tariffs in the Regulated Contracting Environment – ACR, prices in the Free Contracting Environment – ACL, the Settlement Price for Differences – PLD, and marginal costs of generation, transmission, and distribution), state policies (ANEEL regulatory frameworks, energy auctions, incentives for distributed generation and the energy transition), and corporate strategies (investments in renewable energy, tariff risk management, sustainability incorporation, and adaptation to new business models) emerges as a central element for understanding the sector's trajectory and its socioeconomic and environmental impacts.

This literature review precisely delimits its scope to the Brazilian electricity sector, with an emphasis on renewable sources (photovoltaic solar, biogas, biomass, and wind), distributed generation, and energy pricing and commercialization mechanisms. “Energy price” is understood here as the set of economic variables that directly affect the final consumer tariff and project feasibility: generation costs, PLD volatility, loss costs, and the internalization of environmental externalities. The state policies analyzed are those that define rules, incentives, and barriers (reverse auctions, distributed generation regulation, and decarbonization goals), while corporate strategies encompass the responses of generating, distributing, and trading companies to price volatility and sustainability requirements.

An integrated understanding of these three pillars—prices, policies, and strategies—is essential not only for sector stakeholders but also for public policymakers and researchers. Recent literature has explored these interconnections, ranging from the geopolitics of the energy transition to the economic feasibility of specific projects and strategic behavior in auctions.

Given the relevance and complexity of the theme, this article conducts a systematic scientific literature review on “Electricity prices, state policies, and corporate strategies in

the Brazilian electricity sector" using the ProKnow-C method. The primary objective is to identify, select, and critically analyze the most relevant works published between 2020 and 2025, mapping not only trends and findings in national academic production but also the tensions and gaps permeating the relationship between the State, the market, and energy costs.

2. METHODOLOGY

The literature selection for this review was based on the ProKnow-C method (Knowledge Development Process - Constructivist), proposed by Ensslin, Ensslin, Lacerda and Tasca (2010). This tool facilitates a structured and rigorous article selection process through the use of keywords that define the explored thematic axis. The method comprises four stages: (I) selection of the bibliographic portfolio, (II) bibliometric analysis, (III) systematic analysis, and (IV) recommendations for the research question and overarching objective.

The ProKnow-C process begins with a precise definition of the research theme and the axes of interest. Subsequently, the researcher identifies keywords and constructs a search string to be applied in scientific databases chosen for their relevance to the field of study. An initial search generates a raw set of articles, followed by a multi-step filtering and selection phase. The first step involves identifying and removing duplicate articles. The remaining articles are then screened based on title analysis, selecting those with the greatest preliminary alignment with the theme. A key feature of ProKnow-C is the evaluation of the pre-selected articles' relevance based on their scientific recognition, measured by citation counts in databases such as Web of Science, Scopus, or Google Scholar. The Pareto Principle (80/20) is applied at this stage, categorizing articles into those with the highest citation counts (representing the majority of citations) and others. This step prioritizes high-impact works while not necessarily excluding less-cited articles that may hold specific relevance or be very recent. Following this quantitative classification, the abstracts of the most-cited articles are reviewed, along with those of articles from the past two years by prominent authors. Articles deemed relevant after abstract analysis proceed to full-text reading. This comprehensive review enables the final selection of articles that will form the research's bibliographic portfolio, which is then used in subsequent analyses.

The bibliometric analysis aims to assess the portfolio's relevance to the research, identifying patterns and trends.

The systematic analysis involved reading the bibliographic portfolio and observing the following factors: each work's contribution to the proposed theme, the activities conducted within each study, whether a case study was performed, and the techniques and approaches employed.

3. PORTFOLIO SELECTION

The The application of the ProKnow-C method to construct the bibliographic

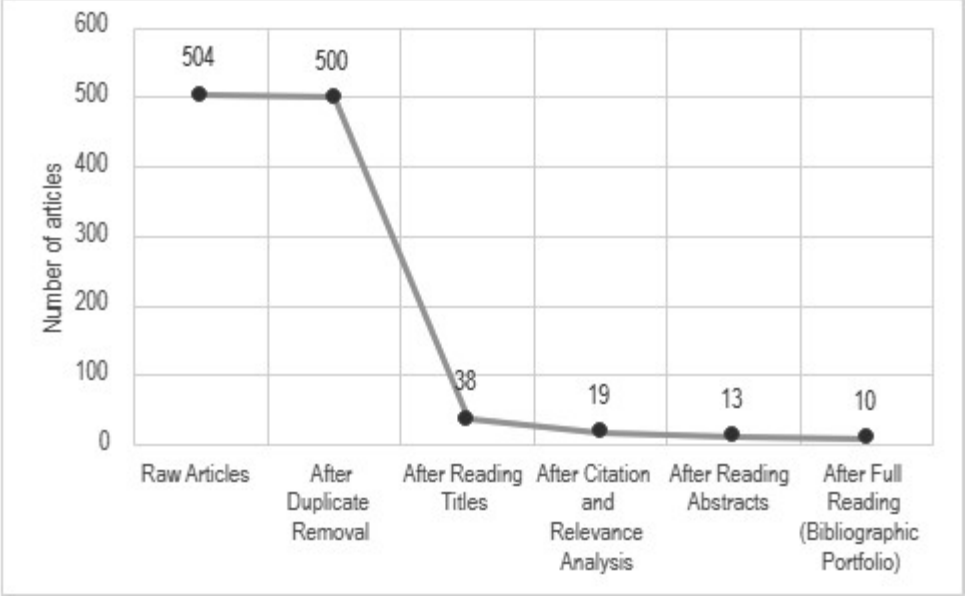
portfolio for this review followed a rigorous quantitative and qualitative process. The initial search, conducted on May 30, 2025, in the Capes Periodicals Portal, used the following search string: "brasil" AND energy AND ("price" OR "cost" OR "tariff" OR "market" OR "economy" OR "pricing" OR "public policy" OR "state policy" OR "government regulation" OR "regulation" OR "state incentive" OR "national policy" OR "government intervention" OR "corporate strategy" OR "business strategy" OR "management" OR "corporate planning" OR "business model" OR "transition strategy").

With applied filters (Portuguese, from 2020 onward, open access, peer-reviewed), this search yielded 504 articles.

- **First Filtering Stage:** Duplicate removal. Four duplicate articles were identified and excluded, leaving 500 unique articles for further analysis.
- **Second Filtering Stage:** Title screening of the 500 articles, assessing their alignment with the central research theme ("Energy prices, state policies, and corporate strategies in Brazil"). This resulted in the selection of 38 articles.
- **Third Filtering Stage:** Scientific relevance analysis of the 38 articles, based on citation counts (Google Scholar) and the Pareto criterion (80/20). This divided the articles into two groups:
    - **Group 1:** Articles accounting for 80% of citations, totaling 10 articles.
    - **Group 2:** Articles not in the top 80% of citations, totaling 28 articles, of which 9 remained after considering the most recent publications (from the last two years) and those by prominent authors.
- **Fourth Filtering Stage:** Abstract review of articles from Groups 1 and 2, totaling 13 articles.
- **Fifth and Final Filtering Stage:** Full-text reading, resulting in a final portfolio of 10 articles.

Figure 1 below illustrates the number of articles observed at each stage:

Figure 1: Number of Articles per Stage in the Bibliographic Portfolio Selection.



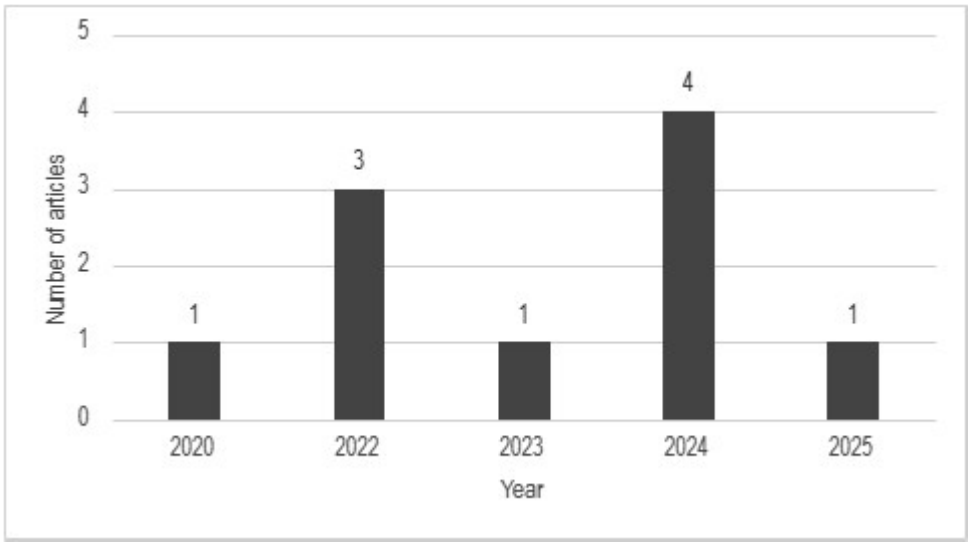
Source: Prepared by the authors.

4. BIBLIOMETRIC ANALYSIS

The bibliometric analysis of the selected bibliographic portfolio on "Energy prices, state policies, and corporate strategies in Brazil" provides a profile of the relevant scientific production identified.

A concentration of publications is observed in the more recent years of the analyzed period (2020–2025), as detailed in Figure 2. The output began with one article in 2020, increased to three articles in 2022, peaked at four articles in 2024, and included one article each in 2023 and 2025. This temporal distribution suggests growing interest or heightened visibility of the topic in recent years, particularly in 2024, possibly reflecting the evolving dynamics of the Brazilian energy sector and its academic discourse.

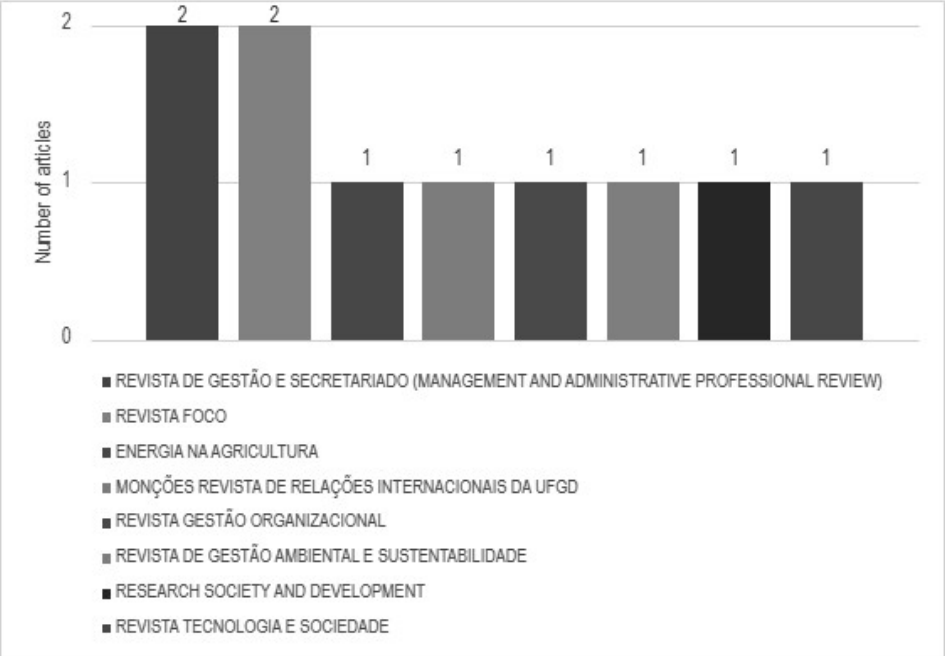
Figure 2: Annual Distribution of Scientific Production (2020 - 2025).



Source: Prepared by the authors.

The analysis of publication sources (journals), presented in Figure 3, shows that the 10 articles in the portfolio are distributed across eight distinct journals. There is a slight concentration, with "Revista de Gestão e Secretariado" and "Revista Foco" each contributing two articles. The remaining six articles were published individually in the following journals: "Energia na Agricultura," "Monções Revista de Relações Internacionais da UFGD," "Revista Gestão Organizacional," "Revista de Gestão Ambiental e Sustentabilidade," "Research Society and Development," and "Revista Tecnologia e Sociedade." This variety of sources indicates that the topic is addressed from multiple disciplinary perspectives and in journals with diverse scopes, spanning management, international relations, agriculture, sustainability, and technology.

Figure 3: Most Relevant Journals.



Source: Prepared by the authors.

In summary, the bibliometric analysis of the portfolio highlights recent scientific production distributed across various academic sources, underscoring the contemporary relevance and multidisciplinary nature of the theme linking energy prices, state policies, and corporate strategies in Brazil.

5. SYSTEMATIC ANALYSIS

The systematic analysis of the 10 articles comprising the bibliographic portfolio provides a deeper understanding of the interconnections between electricity prices, state policies, and corporate strategies within the recent Brazilian context. Although quantitatively limited, the composition of this portfolio is a direct result of the rigorous relevance filters, thematic adherence, and scientific prestige established by the ProKnow-C method, as well as the authors' selection bias. Such delimitation ensures that the subsequent analysis is based on high-impact works precisely aligned with the research axis, prioritizing analytical density. This analysis is organized into a descriptive review of the selected works, followed by an analytical synthesis that identifies structural tensions and convergences in the sector, concluding with the identification of research gaps.

5.1 DESCRIPTIVE REVIEW OF THE BIBLIOGRAPHIC PORTFOLIO

A central axis identified in the selected literature refers to the geopolitical dimension and the state policies shaping Brazil's energy transition. Abrão's (2022) analysis of the global energy transition reveals that the reconfiguration of geopolitical power relations positions Brazil as a potential protagonist due to its vast availability of

renewable resources. The results indicate that adopting policies that promote regional integration and the development of local value chains is essential to overcoming dependence on external technologies and investments, thereby enabling the realization of this potential. The study emphasizes that the geopolitics of renewable energy encompasses not only energy security but also issues of sovereignty, technological development, and international cooperation, which are fundamental to strengthening Brazil's role in the global energy landscape.

Weirich, Souza, Nogueira, and Nadaleti (2022) highlight Brazil's substantial untapped potential for distributed electricity generation from solar photovoltaic and biogas sources. The results indicate that, despite an existing regulatory framework aimed at encouraging this generation model, significant barriers persist, including bureaucratic complexity, a lack of accessible financing, and the need for clearer grid connection regulations. The study suggests that simplifying processes and establishing more robust incentive mechanisms are critical for Brazil to fully realize its potential in distributed generation, contributing to the diversification of the energy matrix and the decentralization of energy production.

Additionally, Rossato, Santos, Barbedo, Silva, and Silva (2024) reveal that treated water losses in Brazil result in substantial and avoidable financial, energy, and greenhouse gas emission costs. The results quantify the economic and environmental impact of this waste, highlighting inefficiencies in the management of water and energy infrastructure. The study demonstrates that improving infrastructure, implementing monitoring technologies, and adopting effective public policies to reduce losses are fundamental to mitigating these impacts. The research underscores that the interconnection between water and energy management is a critical point for the sustainability and efficiency of the sector, noting that inadequate policy decisions can exacerbate these issues.

Another fundamental theme refers to market dynamics, pricing mechanisms, and economic aspects associated with energy sources. The study by Lima and Impinnisi (2024) demonstrates the technical and economic feasibility of implementing photovoltaic systems and energy storage in Brazilian industries. The results indicate that, despite the initial investment, these systems provide significant long-term reductions in energy costs, greater supply security, and reduced exposure to market price volatility. The research also highlights the importance of tax incentives and specific credit lines to accelerate the adoption of these technologies in the industrial sector, contributing to corporate sustainability and competitiveness.

Balle and Marinho (2024) establish a correlation between customer satisfaction, commercial losses, and default rates among electricity distributors. The results suggest that consumer dissatisfaction can lead to an increase in non-technical losses, such as energy theft, and higher default rates, negatively impacting the financial health of distributors. The study recommends investments in service quality improvement, effective communication channels, and consumer education programs to reduce losses and defaults, fostering a healthier relationship between distributors and their customers.

The analysis by Oliveira and Carneiro (2020) reveals that, despite the significant potential of urban solid waste (USW) biomass for energy generation in Brazil, its utilization remains incipient. The results indicate that a lack of coordination among stakeholders, the limited technical and financial capacity of municipalities, and the absence of clear policy guidelines and specific financing lines hinder the widespread adoption of this energy source. The study observes that, as of May 2019, energy recovery from USW represented only 0.096% of the national energy matrix, highlighting the need for more effective and integrated public policies to boost the sector.

Corporate strategies and business management in the energy sector constitute a third thematic cluster. The case study by Silva and Streit (2023) demonstrates that both Raízen S/A and Engie Brasil Energia have sought to align their corporate strategies with the Sustainable Development Goals (SDGs). The results show that these companies are integrating sustainability practices into their operations, investing in renewable energy, energy efficiency, and responsible resource management. The research emphasizes that adopting the SDGs not only contributes to corporate social responsibility but also generates business value by enhancing reputation, attracting investments, and promoting innovation in an increasingly sustainability-conscious market.

Mauricio Junior, Botelho, Botelho, Pakes, and Martins (2025) identify that the solar energy market in Brazil presents significant challenges and opportunities. The results indicate that, despite the sector's exponential growth, obstacles such as bureaucracy, a lack of qualified labor, regulatory instability, and the need for grid infrastructure investments persist. Conversely, the study points to opportunities such as Brazil's vast solar potential, growing demand for clean energy, declining technology costs, and increasing environmental awareness. The research suggests that companies capable of navigating these challenges and capitalizing on such opportunities will be positioned to lead the solar energy market in Brazil.

The application of the ALICE model to reverse energy auctions in Brazil by Ferreira (2024) provides insights into companies' strategic behavior. The results demonstrate that the model is effective in determining equilibrium points, allowing for a better understanding of how companies formulate their bids in a competitive and regulated environment. The study highlights that information asymmetry, risk aversion, and expectations regarding future market conditions influence corporate bidding strategies, and that optimizing auction mechanisms can lead to more efficient and beneficial outcomes for the sector.

Finally, the analysis of the 2001 energy crisis in Brazil conducted by Almeida, Simões, Kurita, Santos, Simões, and Domingues (2022) offers valuable lessons for preventing future events. The results indicate that the crisis was multifactorial, involving climatic factors, planning failures, underinvestment in infrastructure, and regulatory deficiencies. The study emphasizes the importance of robust risk management, diversification of the energy matrix, continuous infrastructure investments, and an adaptable regulatory framework to ensure system resilience. The research concludes

that learning from past crises is essential for developing corporate strategies and public policies that promote the security and stability of the electricity sector.

5.2 ANALYTICAL SYNTHESIS: TENSIONS AND CONVERGENCES

Beyond individual contributions, the synthesis of the portfolio reveals that the relationship between price, policy, and strategy in Brazil is marked by structural tensions. A cross-analysis of the articles allows for the identification of three main axes of contradiction, which are summarized in Table 1.

Table 1: Analytical Matrix of Interdependence in the Electricity Sector

Analytical Axis	Identified Conflict (Tension)	Convergent Articles
A) Public Policy & Implementation	Geopolitical Potential vs. Bureaucracy and Infrastructure Gaps	Abrão (2022); Mauricio Jr. (2025); Oliveira & Carneiro (2020); Weirich et al. (2022)
B) Price Signaling & Strategic Risk	PLD Volatility vs. Defensive Strategies (ESG/Self-generation)	Ferreira (2024); Silva & Streit (2023); Lima & Impinnisi (2024); Almeida et al. (2022)
C) Efficiency & Pricing	Operational Inefficiency (Losses) vs. Financial Sustainability	Rossato et al. (2024); Balle & Marinho (2024)

Source: Prepared by the authors.

A) The Gap Between Geopolitical Potential and Economic Feasibility: Although Abrão (2022) positions Brazil as a global protagonist, the works of Mauricio Junior et al. (2025), Oliveira and Carneiro (2020), and Weirich et al. (2022) reveal an implementation inertia. The conflict resides in the fact that while state policies and natural potential exist, corporate strategies are hindered by bureaucracy and infrastructure gaps that fail to offset the costs of emerging sources compared to traditional ones.

B) Strategic Behavior Under Regulatory Uncertainty and Price Volatility: As shown in Table 1, there is a tension between the volatility of the PLD and the predictability required for investment. Ferreira's (2024) study on auctions connects directly to the strategic responses analyzed by Silva and Streit (2023) and Lima and Impinnisi (2024). Corporate strategy is shaped by an aversion to regulatory risk, where investments in ESG and self-generation act as security mechanisms against price volatility and past planning failures, such as those discussed by Almeida et al. (2022).

C) The Cycle of Inefficiency and Pricing: The third tension involves the correlation between infrastructure losses and the sector's financial health. Rossato et al. (2024) and Balle and Marinho (2024) corroborate that inefficiencies in state-

regulated sectors generate "invisible costs" passed on to the final price. This creates a conflict where high tariffs, driven by technical and commercial losses, increase default rates and limit the capacity for strategic innovation, hindering the energy transition.

5.3 ANALYTICAL SYNTHESIS: TENSIONS AND CONVERGENCES

The systematic analysis reveals a fragmented academic landscape in which studies focus on specific niches, such as solar feasibility or auction modeling, without addressing the holistic impact of these variables. This fragmentation is evidenced by the scarcity of research on price dynamics and public policies for the wind and hydroelectric sectors, despite their dominance in the Brazilian energy matrix, as well as the limited exploration of disruptive technologies such as large-scale energy storage and smart grids. There is a clear need for a transition from these isolated observations to a systemic understanding of how price signals and regulatory frameworks converge to define long-term sector efficiency.

Ultimately, this review demonstrates that corporate strategy in the Brazilian electricity sector is rarely a proactive choice; rather, it is largely a defensive reaction to price volatility and regulatory instability. The evidence suggests that when the State fails to provide clear long-term signals, companies prioritize risk mitigation and self-generation as forms of protection, to the detriment of aggressive expansion. Therefore, the synergy between affordable prices, coherent policies, and agile strategies remains a work in progress. Overcoming these organizational silos, in both literature and practice, is not only a research opportunity but a fundamental necessity for the future resilience and sustainability of the Brazilian energy sector.

6. CONCLUSIONS

The analysis of the bibliographic portfolio, grounded in the ProKnow-C method, provided a consolidated and critical view of recent scientific production (2020–2025) regarding the triad of prices, policies, and strategies in the Brazilian electricity sector. More than merely confirming the interdependence of these pillars, this review revealed that the relationship between them is dictated by a cycle of mutual influence, where regulatory fragility and economic volatility force market agents to adopt preventive behaviors. It was observed that corporate strategy in Brazil is predominantly reactive and defensive, such that investments in self-generation and the incorporation of sustainability practices (ESG) function less as a proactive expansion and more as a security mechanism against institutional instability and the volatility of the Settlement Price for Differences (PLD).

In this scenario, the energy price acts as a true thermometer of institutional friction. The evidence demonstrates that tariffs do not merely reflect marginal operating costs but carry the weight of state inefficiencies and historical infrastructure losses, which ultimately raises final costs and reduces the strategic capacity of companies to invest in disruptive innovation. Concurrently, a persistent gap was identified between

Brazil's geopolitical potential in the energy transition and the operational reality of renewable sources. Although Brazil possesses abundant natural resources, the "implementation inertia" caused by bureaucratic barriers and the absence of financing mechanisms for technologies such as energy storage and waste-to-energy recovery prevents this potential from converting into a real competitive advantage.

Finally, the identification of significant gaps in the literature, especially the scarcity of studies on pricing and specific policies for the wind and hydroelectric sectors, as well as smart grid technologies, indicates that academic knowledge and market practice still operate in organizational silos. It is concluded that the resilience of the Brazilian electricity sector depends on a redirecting of State policies, which must evolve from crisis responses to the provision of long-term price signals. Only through a systemic alignment between the regulator and the market will it be possible to overcome current fragmentation and ensure energy development that is simultaneously sustainable and economically viable for the country.

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