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Geoeconomics of the Energy Transition and the Geopolitics of Strategic Resources: Implications for Sustainable Development in Brazil

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Abstract:
Background: *The global energy transition has generated profound changes in the interactions among economic systems, technological development, natural resources, and sustainable development, fostering new productive, commercial, and geopolitical arrangements associated with the establishment of low-carbon energy matrices. In this context, strategic resources, particularly critical minerals used in renewable energy technologies, have become increasingly important in international relations, highlighting the need to investigate the connections between geoeconomics, geopolitics, and sustainability. Therefore, this study aimed to analyze the interrelationships between the geoeconomics of the energy transition and the geopolitics of strategic resources, considering their implications for sustainable development in Brazil amid ongoing global energy transformations.*
Materials and Methods: *This study adopted a qualitative research approach. Two complementary methods were employed to achieve the research objectives: a bibliographic review and documentary research. These methods enabled the examination of the economic, productive, technological, and geopolitical factors shaping the contemporary energy transition and their potential consequences for Brazil.*
Results: *The findings indicate that the global energy transition is reshaping the interaction among economic systems, technological innovation, natural resources, and geopolitical power, increasing the strategic relevance of critical minerals and renewable energy sources. The analysis revealed that Brazil has significant potential to become a leading actor in the emerging global energy order due to its abundance of strategic resources and diversified energy matrix. However, transforming these advantages into sustainable development outcomes requires the implementation of policies that promote innovation, value addition, industrialization, and the effective management of natural resources.*
Conclusion: *The study concludes that the interrelationship between geoeconomics, the geopolitics of strategic resources, and sustainability is essential for strengthening Brazil's competitiveness and enhancing its contribution to the energy transition of the twenty-first century. Strategic planning and public policies aimed at resource governance and technological development are fundamental to ensuring that the opportunities arising from the global energy transition translate into long-term sustainable development benefits.*
Key Word*: Energy Transition; Geoeconomics; Strategic Resources; Sustainable Development.*

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I. Introduction

The energy transition represents one of the most significant processes among the economic, technological, and environmental transformations characterizing the twenty-first century. Driven by the urgency of reducing greenhouse gas emissions, enhancing energy security, and fulfilling international commitments related to climate change, this transition is reshaping productive structures and development models across the globe. In this context, the diversification of renewable energy sources, coupled with advances in industrial technologies, has increased the strategic relevance of natural resources essential for sustaining low-carbon economies.

It is important to recognize that the energy transition is not an isolated technical process but rather occurs within a context of overlapping energy systems. Although renewable energy sources continue to expand, hydrocarbons still account for the largest share of the global energy matrix, intensifying competition for the resources that support both traditional and emerging energy models. This scenario constitutes a dual transition, encompassing both energy and geopolitical dimensions, and requires Brazil to strengthen its technological sovereignty and capacity for strategic influence amid the competing interests of major global powers.

Simultaneously, the growing demand for critical minerals and strategic resources, which are indispensable for the production of batteries, electric vehicles, energy storage systems, electronic devices, and renewable energy technologies, has brought renewed prominence to contemporary geopolitical discussions. Control over mineral reserves, processing chains, and international flows of raw materials has increasingly shaped economic, commercial, and diplomatic decisions worldwide. In this context, countries endowed with abundant energy and mineral resources are becoming key actors in strategies related to energy security, economic competitiveness, and sustainable development. Among these nations, Brazil stands out due to the diversity of its energy matrix, the availability of strategic mineral resources, and its capacity to integrate into global markets associated with the energy transition.

Accordingly, the present study seeks to investigate how the geoeconomics of the energy transition and the geopolitics of strategic resources are interconnected and to examine the implications of this relationship for sustainable development in Brazil amid ongoing global energy transformations. The specific objectives are: (i) to examine the geoeconomics of the energy transition, with emphasis on the economic, productive, and technological changes associated with the adoption of low-carbon energy matrices; (ii) to analyze the geopolitics of strategic resources within the context of the global energy transition, considering the relevance of critical minerals and international competition for natural resources; (iii) to investigate the implications of the geoeconomics of the energy transition and the geopolitics of strategic resources for sustainable development in Brazil; and (iv) to evaluate Brazil's strategic role within the emerging global energy order, considering its potential in the energy and strategic minerals sectors.

Regarding the methodological approach, this study adopts a qualitative research design. Two complementary methods were employed: a bibliographic review and documentary research. These procedures enabled the collection and analysis of information derived from specialized scientific literature and institutional documents addressing energy transition, strategic resources, geoeconomics, and sustainable development, thereby providing a comprehensive understanding of the dynamics shaping the object of study.

In order to achieve the proposed objectives, the article is structured into four main sections. The first section consists of this Introduction, which contextualizes the topic, presents the research objectives, and outlines the methodological approach. The second section describes the methods employed in the investigation. The third section presents the Theoretical Framework, discussing the principal dimensions of the geoeconomics of the energy transition, the geopolitics of strategic resources, sustainable development in Brazil, and Brazil's position within the emerging global energy order. Finally, the fourth section presents the Conclusions, synthesizing the main findings and reflections derived from the research conducted throughout the study.

II. Material And Methods

The accelerating pace of the global energy transition has promoted profound economic, technological, industrial, and geopolitical transformations, redefining the relationships among states, markets, and strategic natural resources. In this context, the analysis of the interactions between the geoeconomics of the energy transition and the geopolitics of strategic resources becomes particularly relevant for understanding the challenges and opportunities associated with sustainable development in Brazil. The expansion of renewable energy sources, the growing demand for critical minerals, and the reorganization of global value chains have increased the importance of studies capable of examining the impacts of these transformations on countries endowed with strategic natural resources, such as Brazil. Accordingly, the present research seeks to contribute to the understanding of contemporary dynamics that connect energy, economics, development, and power within the international system.

With regard to its methodological approach, this study is characterized as qualitative in nature. This approach is widely employed in the social, economic, and environmental sciences because it enables an in-depth

interpretation of complex phenomena, particularly those involving institutional relationships, historical processes, geopolitical disputes, and structural transformations. Qualitative research facilitates the understanding of meanings, interconnections, and contextual factors that cannot be fully explained through quantitative indicators alone, thereby supporting more comprehensive analyses of the multiple dimensions involved in the energy transition and the reorganization of the global geoeconomic landscape (Creswell & Creswell, 2018).

To conduct the investigation, two complementary methodological procedures were employed: a bibliographic review and documentary research. The bibliographic review constitutes one of the most widely used instruments in international scientific production, as it enables the identification, systematization, and critical analysis of existing knowledge on a given subject. Through this procedure, it is possible to understand the evolution of academic debates, identify theoretical convergences and divergences, and establish robust analytical foundations for the development of research. In the present study, the bibliographic review was based on the analysis of scientific articles published in national and international academic journals, as well as specialized books addressing geoeconomics, the geopolitics of strategic resources, energy transition, and sustainable development (Cavalcante & Oliveira, 2020; Arantes, 2025).

Complementarily, documentary research was conducted, a procedure that enables the analysis of institutional documents and technical reports produced by nationally and internationally recognized organizations (Arantes, 2025). Documentary research plays an important role in global scientific production because it provides access to official information, strategic indicators, institutional guidelines, and specialized assessments that contribute to the understanding of contemporary phenomena. In this regard, the following documents were analyzed: *Global Critical Minerals Outlook 2024*, published by the International Energy Agency (IEA, 2024); *Lithium Extraction and Industrialization: Opportunities and Challenges for Latin America and the Caribbean*, published by the Economic Commission for Latin America and the Caribbean (ECLAC, 2023); *Green Economy for Sustainable Development*, published by the Center for Management and Strategic Studies (CGEE, 2012); and *World Energy Transitions Outlook 2023: 1.5°C Pathway*, published by the International Renewable Energy Agency (IRENA, 2023).

The combined use of bibliographic review and documentary research proved appropriate to the objectives of this investigation because it enabled the integration of theoretical contributions, academic analyses, and evidence produced by specialized organizations that monitor global energy transformations. While the bibliographic review provided the conceptual frameworks necessary for understanding the foundations of the geoeconomics of the energy transition and the geopolitics of strategic resources, documentary research made it possible to examine recent trends, institutional data, and international perspectives concerning the dynamics of critical minerals, energy security, and sustainable development. The combination of these procedures contributed to the development of a consistent analysis of Brazil's role within the emerging global energy order and of the implications of ongoing transformations for national sustainable development (Cavalcante & Oliveira, 2020; Creswell & Creswell, 2018; Arantes, 2025).

III. Theoretical Framework

The theoretical framework was organized into four interconnected sections in order to encompass the most relevant analytical dimensions related to the geoeconomics of the energy transition and the geopolitics of strategic resources. First, Section 3.1, entitled *Geoeconomics of the Energy Transition: Economic Transformations and Global Productive Reconfigurations*, examines the principles underlying geoeconomics and the energy transition, emphasizing the economic, technological, and industrial transformations associated with the decarbonization of the global economy. Subsequently, Section 3.2, *Geopolitics of Strategic Resources: Critical Minerals, Energy Security, and International Competition*, investigates the geopolitical significance of critical minerals and strategic resources for the consolidation of clean energy technologies, with particular emphasis on international competition for the control and supply of these essential inputs. Section 3.3, *Geoeconomics, Strategic Resources, and Sustainable Development in Brazil*, analyzes the opportunities and challenges that the energy transition presents for sustainable development in Brazil, considering the country's availability of strategic resources and the transformations occurring within global value chains. Finally, Section 3.4, *Brazil in the Emerging Global Energy Order*, examines Brazil's strategic role in the international arena, highlighting its mineral reserves, predominantly renewable energy matrix, and the competitive opportunities arising from the new economic configurations generated by the global energy transition. Collectively, these four sections provide the

basis for an integrated analysis of the relationships among energy, strategic resources, sustainable development, and contemporary geopolitics.

3.1 Geoeconomics of the Energy Transition: Economic Transformations and Global Productive Reconfigurations

The disruptive process of economic and industrial development has historically been accompanied by increasing greenhouse gas emissions, whose environmental consequences have prompted the international community to undertake a global effort to mitigate atmospheric warming through an energy transition capable of reducing climate-related impacts and their effects on ecosystems worldwide (Barbosa & Gomes, 2024).

For this reason, the energy transition has emerged as one of the principal drivers of the reorganization of the international economy in the twenty-first century. More than a technological shift aimed at replacing fossil fuels with renewable energy sources, this process encompasses profound productive, commercial, and strategic transformations that are reshaping historical patterns of economic development. Within this context, geoeconomics has emerged as an analytical framework capable of explaining how states employ economic, technological, and energy-related instruments to expand their influence and secure advantageous positions within the international system. According to Weingartner Chagas and Loeb Caldenhof (2023), the growing interdependence among economic security, logistics, and strategic intelligence demonstrates that energy resources have assumed a central role in contemporary disputes over competitiveness and sovereignty.

Understanding the geoeconomics of the energy transition requires recognizing that decarbonization processes do not occur uniformly across countries. Differences in technological, industrial, and financial capacities directly influence the pace at which economies can adapt their energy matrices and productive structures. Baumann (2025) argues that the global economic reorganization associated with sustainability has generated new economic hierarchies in which technological innovation and control over strategic value chains have become increasingly significant. Consequently, the energy transition should not be understood solely as an environmental agenda but also as a process of reconfiguring the mechanisms through which wealth and economic power are generated.

From this perspective, the adoption of clean technologies is promoting substantial changes in the global industrial landscape. The expansion of solar and wind energy, low-carbon hydrogen, energy storage technologies, and the digitalization of electricity systems is fostering the emergence of new markets while stimulating large-scale investments in research, development, and infrastructure. According to the International Renewable Energy Agency (IRENA, 2023), a trajectory consistent with the 1.5°C target requires a rapid expansion of renewable energy sources and improvements in energy efficiency, generating direct impacts on investment flows, employment creation, and industrial competitiveness. In this scenario, the capacity to internalize technological innovation becomes a decisive factor for countries seeking a strategic position within the global economy.

In order to synthesize the principal structural elements of the geoeconomics of the energy transition and their implications for global productive transformations, Table 1 is presented below.

Table 1. Geoeconomic Elements of the Energy Transition and Their Impacts on Global Productive Reorganization

Central Elements	Main Characteristics	Economic and Productive Impacts
Decarbonization of the Economy	Reduction of dependence on fossil fuels and expansion of renewable energy sources	Restructuring of energy and industrial sectors
Technological Innovation	Expansion of clean technologies, digitalization, and energy storage systems	Increased competitiveness and productive modernization
Economic Security	Pursuit of energy autonomy and reduction of external vulnerabilities	Strengthening of national development strategies
New Global Value Chains	Growing demand for critical minerals and technological components	Redistribution of investments and industrial opportunities
Geopolitics of Strategic Resources	Competition for inputs essential to the energy transition	Reconfiguration of international and commercial relations
Sustainability and Development	Integration of economic growth and emissions reduction	Promotion of new low-carbon development models

Source: Prepared based on IRENA (2023), Weingartner Chagas and Loeb Caldenhof (2023), Cataia and Duarte (2022), Baumann (2025), and Martins and Nonnemberg (2025).

The analysis of the energy transition also requires careful consideration of its territorial and spatial dimensions. Cataia and Duarte (2022) argue that energy transformations cannot be understood exclusively through technological or economic indicators, as they involve disputes over territorial appropriation, the reorganization of infrastructure systems, and the redefinition of relationships among nature, society, and production. From this

perspective, the expansion of renewable energy projects modifies regional dynamics, creates new economic hubs, and generates diverse socio-environmental impacts, thereby requiring integrated analytical approaches for a comprehensive understanding.

The discussion of territory and development finds theoretical support in the contributions of Santos (2009), whose interpretation emphasizes the relationship among technology, space, and social organization. According to the author, technological transformations directly influence territorial configurations and the spatial distribution of economic activities. Applied to the contemporary context, this perspective makes it possible to understand that the energy transition is not limited to the substitution of energy sources; rather, it promotes new forms of spatial organization, redefines productive networks, and alters patterns of capital, information, and knowledge flows on a global scale.

Another relevant aspect concerns the transformations observed in international trade and in the economic policy strategies adopted by states. Martins and Nonnenberg (2025) identify that the strengthening of industrial policies, technological protection mechanisms, and incentives for domestic production has accompanied the expansion of the green economy in several regions of the world. This movement demonstrates that the energy transition is associated with new forms of international economic competition, in which technological leadership and control over strategic sectors play increasingly prominent roles. In this sense, geoeconomics becomes an interpretative framework capable of explaining the growing articulation among sustainability, competitiveness, and economic security.

Finally, although fossil fuels continue to exert significant influence on international relations, a gradual diversification of the material foundations of global power can be observed. Silva and Peixinho (2025) demonstrate that energy has historically constituted an instrument of geopolitical projection, particularly through the strategic role of oil. However, the emergence of renewable technologies and the increasing importance of resources associated with decarbonization point toward a new configuration of economic and strategic competition. In this context, the geoeconomics of the energy transition emerges as an indispensable analytical field for understanding global productive transformations and their implications for countries such as Brazil, whose availability of natural resources, renewable energy generation capacity, and territorial diversity may significantly influence its position within the international energy landscape in the coming decades.

The reconfiguration of global value chains has consolidated the nexus between energy and minerals. Unlike combustion-based systems, in which resources are consumed during use, clean energy technologies incorporate minerals into equipment that provides services over extended life cycles, allowing future recycling and reuse through secondary stocks, as explained by Castro et al. (2024).

In Brazil, according to EPE (2025a), the renewable share of the electricity matrix is projected to remain close to 90% through 2034. The leading role of wind and solar energy sources will require substantial increases in mineral production and significant investments in battery storage technologies to ensure system flexibility and reliability.

3.2 Geopolitics of Strategic Resources: Critical Minerals, Energy Security, and International Competition

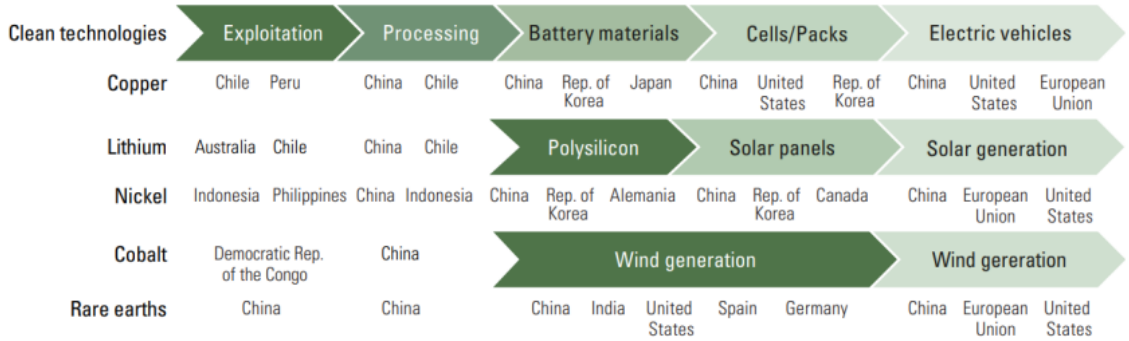
Recent technological transformations and innovations have demonstrated how mineral production is becoming one of the principal drivers of the global energy reconfiguration, whose dominant axis is the transition from traditional fossil fuel-based energy sources to renewable energy systems (Castro et al., 2024). For this and other reasons, the global energy transition has elevated strategic minerals to a position of geopolitical centrality, particularly those required for the production of batteries, solar panels, wind turbines, energy storage systems, and electric vehicles. In this regard, minerals such as lithium, copper, nickel, cobalt, and rare earth elements have gained increasing prominence within the economic and national security agendas of major powers. According to the International Energy Agency (IEA, 2024), the expansion of low-carbon technologies has resulted in a substantial increase in the demand for critical minerals, making control over their production and supply chains one of the primary drivers of global economic competition. This development demonstrates that energy security can no longer be understood solely in terms of access to fossil fuels, but rather as the ability to ensure a stable and secure supply of the raw materials essential for the decarbonization of the global economy (IEA, 2024; Reis et al., 2025).

It is important to emphasize that the International Energy Agency projects a rapid increase in global demand for critical minerals over the coming decades as decarbonization policies continue to expand worldwide (IEA, 2024). Contemporary scholarship indicates that the geopolitics of critical minerals differs substantially from the traditional geopolitical disputes associated with oil and natural gas. Although hydrocarbons continue to play an important role in international relations, strategic minerals are now embedded within a new structure of economic power based on technological, industrial, and productive capabilities. As highlighted by Silva and Peixinho (2025), energy has historically been associated with states' capacity to project influence; however, the

contemporary energy transition introduces new vectors of international rivalry related to the control of global value chains, technological innovation, and the security of mineral supplies. Consequently, the geopolitics of the energy transition does not replace historical rivalries but rather adds new dimensions associated with the resources required for the expansion of renewable energy technologies.

The geographical concentration of mineral reserves constitutes one of the principal factors that make these resources increasingly strategic. Argentina, Bolivia, and Chile, which together form the so-called "Lithium Triangle," account for a significant share of global lithium reserves, while the Democratic Republic of the Congo is the world's leading cobalt producer and China occupies a dominant position in the processing of rare earth elements and refined minerals (ECLAC, 2023; Maldonado-Ibarra et al., 2024). This concentration creates vulnerabilities within global supply chains and intensifies concerns among importing countries regarding external dependence on inputs that are essential to their industrial and energy policies. The distribution of extraction, processing, component manufacturing, and clean technology production activities throughout the global value chains of critical minerals, as well as the role played by different countries at each stage of these chains, is illustrated in Figure 1.

Figure 1. Participation of Different Countries in Selected Activities Along Critical Mineral Value Chains



Source: CEPAL (2023)

Based on the analysis of Figure 1, it is possible to observe that only a limited number of countries control the strategic stages of critical mineral value chains. China is particularly dominant in mineral processing, the production of battery and solar panel materials, and the manufacturing of industrial components, thereby securing a leading position in both technology development and industrial production. This dynamic demonstrates that the geoeconomic power associated with critical minerals extends beyond the mere possession of natural reserves, encompassing the capacity to generate value through industrialization, technological control, and a strategic integration into global production networks (ECLAC, 2023; IEA, 2024).

In order to summarize the principal strategic resources of the energy transition and their geopolitical implications, Table 2 is presented below.

Table 2. Critical Minerals, Technological Applications, and Geopolitical Implications in the Global Energy Transition

Strategic Mineral	Main Applications	Major Producers or Processors	Geopolitical Relevance
Lithium	Batteries for electric vehicles and energy storage systems	Chile, Argentina, Bolivia, China, and Australia	Competition for control of reserves and industrial value addition
Copper	Power grids, renewable energy generation, and electric vehicles	Chile, Peru, and China	Essential for the electrification of the global economy
Nickel	High-energy-density batteries	Indonesia, the Philippines, and China	Increasing importance for the electric mobility industry
Cobalt	Battery components and advanced technologies	Democratic Republic of the Congo and China	High concentration of production and supply risks

Strategic Mineral	Main Applications	Major Producers or Processors	Geopolitical Relevance
Rare Earth Elements	Permanent magnets, wind turbines, and electronic equipment	China, the United States, and Australia	Strong influence on strategic technology supply chains
Graphite	Battery anodes and energy storage systems	China, Mozambique, and Brazil	Growing relevance for energy storage technologies

Source: Prepared based on IEA (2024), ECLAC (2023), Reis et al. (2025), Maldonado-Ibarra et al. (2024), Brazilian Mining Association (IBRAM, 2025), and Dominish et al. (2019).

The growing strategic importance of critical minerals has also intensified discussions regarding the socio-environmental sustainability of extraction activities. Florin and Teske (2019) observe that the increasing adoption of renewable energy sources does not automatically eliminate environmental and social impacts, particularly when mining operations occur in environmentally sensitive areas or within the territories of traditional communities. Therefore, energy security and sustainability must be addressed through an integrated approach that considers not only resource availability but also the conditions under which resources are extracted, processed, and utilized throughout global value chains.

The geopolitics of these resources is characterized by a high degree of geographical concentration, not only in extraction activities but especially in processing operations, where China controls between 40% and 80% of materials such as lithium, cobalt, and rare earth elements, according to studies conducted by the Energy Research Office (EPE, 2025a). Within the Latin American context, critical minerals represent both an economic opportunity and a strategic challenge. According to Reis, Oliveira, and Pieri (2025), the region possesses favorable conditions to strengthen its participation in the global value chains associated with the energy transition, particularly due to its abundance of mineral and energy resources. However, maintaining economic models based primarily on commodity exports may limit the benefits derived from the emerging low-carbon economy. Maldonado-Ibarra et al. (2024) argue that value addition, local processing, and the strengthening of technological capabilities are essential for maximizing economic gains and mitigating the historical asymmetries that continue to characterize international economic relations.

In the case of Brazil, the context presents particularly significant opportunities. The country possesses substantial reserves of lithium, graphite, nickel, copper, manganese, and rare earth elements, in addition to a predominantly renewable electricity matrix. According to the Brazilian Mining Association (IBRAM, 2025), this combination places Brazil in a favorable position within the ongoing global energy transformation. Nevertheless, Dorneles, Ventura, and Almeida (2021) emphasize that converting this mineral advantage into sustainable development requires coordinated state action, consistent industrial policies, and strategies that promote technological innovation, value addition, and competitiveness within international value chains.

To mitigate supply risks and strengthen national security, Brazil established its own list of strategic minerals through Resolution No. 2/2021 of the Ministry of Mines and Energy (MME), prioritizing resources for which the country remains dependent on imports, particularly in the fertilizer sector, as well as minerals considered essential for low-carbon technologies. Consequently, the geopolitics of strategic resources extends beyond the minerals themselves and becomes fundamentally associated with decisions concerning economic sovereignty, energy security, and the sustainable development of Brazil.

3.3 Geoeconomics, Strategic Resources, and Sustainable Development in Brazil

The current energy transition is driving profound transformations in the global economy, reshaping production patterns, trade routes, and national strategies aimed at positioning countries within the emerging dynamics of sustainable development. In this context, Brazil occupies a particularly advantageous position due to its combination of abundant natural resources, an energy matrix characterized by a substantial share of renewable sources, and significant reserves of strategic minerals essential for low-carbon technologies. However, converting these advantages into sustainable development requires the integration of industrial policies, technological innovation, and long-term planning, rather than maintaining economic models based predominantly on commodity exports. As argued by Sousa (2023) and the Centro de Gestão e Estudos Estratégicos (CGEE, 2012), sustainable development emerges from the balance among economic growth, social inclusion, and environmental protection, particularly during periods marked by major technological and energy transformations.

The growing relevance of geoeconomics in international relations is also reshaping the conditions of competitiveness among states. According to Babic et al. (2024), contemporary disputes increasingly incorporate economic, technological, and regulatory instruments designed to expand international influence and protect sectors regarded as strategically important. Similarly, Wigell et al. (2022) emphasize that geoeconomic risks arising from global supply chains, trade barriers, and geopolitical tensions have become a permanent feature of the international environment. For Brazil, this reality reinforces the urgency of developing mechanisms of economic resilience capable of strengthening strategic sectors associated with renewable energy, sustainable mining, and the manufacturing industries linked to the energy transition.

Brazil's emerging position in the international arena can be understood through the convergence of strategic resources, productive capacity, and sustainability. To summarize the principal opportunities and challenges shaping this relationship, Table 3 is presented below.

Table 3. Opportunities and Challenges of the Geoeconomics of the Energy Transition for Sustainable Development in Brazil.

Dimension	Opportunities for Brazil	Associated Challenges
Strategic Mineral Resources	Availability of lithium, graphite, nickel, copper, and rare earth elements	Limited value addition and continued dependence on raw material exports
Energy Matrix	High share of renewable energy sources	Expansion of infrastructure and technological modernization
National Industry	Integration into global clean technology value chains	Low technological intensity in advanced industrial sectors
International Trade	Expansion of markets associated with the green economy	Growth of geoeconomic barriers and trade disputes
Sustainability	Potential for leadership in the low-carbon economy	Need to balance economic exploitation with environmental protection
Technological Innovation	Development of new domestic productive value chains	Insufficient investments in research, development, and innovation

Source: Prepared by the author based on CGEE (2012), Wigell et al. (2022), Sousa (2023), Babic et al. (2024), Baldwin (2019), and Baumann (2025).

The benefits of the energy transition, as highlighted in Table 3, depend not only on the availability of natural resources but also on each country's capacity to internalize knowledge, technology, and higher value-added industrial activities. This perspective is supported by Baldwin (2019), who argues that the new phase of globalization has been profoundly shaped by the diffusion of knowledge, innovation, and digital technologies. Consequently, countries that successfully combine strategic resources with technological capabilities tend to occupy more advantageous positions within global value chains. Merely acting as a supplier of raw materials may prevent Brazil from capturing the full range of economic benefits associated with the energy transition, thereby limiting its potential contribution to national development.

Brazil's productive structure constitutes another key factor in understanding the opportunities and constraints of the emerging geoeconomic landscape. According to Baumann (2025), Brazil's international integration remains strongly linked to the export of primary commodities, a condition that constrains value creation and reduces the country's ability to capitalize on the economic gains arising from technological transformations in the global economy. The energy transition therefore represents both an opportunity for productive diversification and a challenge that requires the strengthening of industrial policies, increased investment in research, and incentives for the domestic production of components related to renewable energy, electric mobility, and energy storage technologies.

Beyond economic considerations, the pursuit of sustainable development in Brazil must also address the social and environmental impacts associated with the expansion of productive activities linked to the green economy. The Centro de Gestão e Estudos Estratégicos (CGEE, 2012) emphasizes that the consolidation of a sustainable economy requires the implementation of strategies that integrate economic efficiency, environmental preservation, and social inclusion. Sousa (2023) further argues that sustainable development should be understood as a multidimensional process in which economic growth, social equity, and the conservation of natural resources are intrinsically interconnected. Accordingly, the exploitation of strategic resources in Brazil should be conducted through robust governance mechanisms, environmental monitoring, and active societal participation, ensuring that the resulting benefits remain sustainable for both present and future generations.

Finally, the transformations associated with the geoeconomics of the energy transition suggest that Brazil's sustainable development will increasingly depend on its ability to combine natural resources, technological innovation, state planning, and strategic international integration. As highlighted by Wigell et al. (2022), Babic et al. (2024), and Baumann (2025), countries capable of reducing external vulnerabilities while

expanding their presence in technologically advanced sectors will be better positioned to address the challenges posed by the new geoeconomic environment. In this regard, Brazil possesses a unique set of conditions that could enable it to assume a leading role in the low-carbon economy. However, achieving this objective will require transforming its comparative advantages into competitive advantages, supported by knowledge generation, industrialization, and technological development.

3.4 Brazil in the New Global Energy Order

To understand Brazil's position within the emerging global energy order, it is essential to recognize that the energy transition has evolved beyond a purely environmental agenda and has become a major driver of economic, technological, and geopolitical restructuring worldwide. The growing demand for renewable energy, critical minerals, and low-carbon technologies is reshaping trade flows, investment patterns, and national development strategies. Within this context, countries capable of combining abundant natural resources, energy infrastructure, and productive capacity are likely to secure privileged positions within global value chains. The International Renewable Energy Agency (IRENA, 2023) argues that the expansion of renewable energy constitutes one of the principal forces driving contemporary economic transformations, requiring new models of international cooperation and innovative forms of productive integration. For Brazil, this scenario represents an opportunity to expand its participation in global markets associated with the energy transition while simultaneously reinforcing sustainable development strategies.

Brazil possesses significant competitive advantages derived from its predominantly renewable electricity matrix, the availability of strategic natural resources, and its territorial diversity, which enables the development of a broad range of clean energy sources. The study conducted by Cataia and Duarte (2022) emphasizes that the interaction among territory, energy resources, and economic development is crucial for understanding the emerging dynamics of the energy transition. Furthermore, the territorial perspective proposed by Santos (2009) suggests that natural resources become strategic through the technical, economic, and political connections established at both national and international levels. Consequently, Brazil's position within the new energy order depends not only on the physical availability of resources but also on its capacity to transform them into sources of wealth generation, technological innovation, and regional development.

Another important consideration is the increasing significance of critical minerals for the advancement of clean energy technologies. Lithium, nickel, copper, rare earth elements, and graphite have become essential inputs for batteries, electric vehicles, energy storage systems, and renewable energy generation technologies. According to the International Energy Agency (IEA, 2024), global demand for critical minerals is expected to increase substantially over the coming decades as decarbonization policies continue to expand. In this regard, Brazil possesses significant reserves of several minerals that are strategic to a low-carbon economy, thereby enhancing its geopolitical and economic relevance. As highlighted by the Brazilian Mining Institute (IBRAM, 2025), Brazil has the potential to integrate into higher value-added segments of mineral value chains, reducing its dependence on the export of primary commodities.

The role of Latin America in the geopolitics of critical minerals is also closely linked to Brazil's strategic relevance. According to Reis, Oliveira, and Pieri (2025), the region holds valuable mineral reserves associated with the energy transition, making it an increasingly important target of interest for major economic powers. Similarly, Maldonado-Ibarra et al. (2024) argue that Latin American minerals are becoming progressively more significant within global energy security and industrial strategies. Given its abundance of mineral, agricultural, water, and renewable energy resources, Brazil possesses favorable conditions to reduce external dependencies while pursuing a form of international integration grounded in value addition and economic sovereignty.

The transformations characterizing contemporary geoeconomics have also intensified challenges related to international competitiveness and productive integration. According to Babic, Graff, Linsi, and Weinhardt (2024), the growing use of geoeconomic instruments by nation-states is reshaping patterns of trade, investment, and technological innovation. In a similar vein, Martins and Nonnenberg (2025) point to the strengthening of industrial policies, strategic protection measures, and technological disputes among major economies. Baldwin (2019) observes that the convergence of digital technologies with global production networks has significantly altered the international distribution of economic activities. Within this context, Baumann (2025) argues that Brazil's productive structure must advance in technological and industrial diversification to enhance its competitiveness within the emerging energy transition economy.

Beyond economic opportunities, the consolidation of Brazil as a leading actor in the new energy order requires continuous attention to the geopolitical risks associated with competition for strategic resources and shifts in global investment flows. Weingartner Chagas and Loeb Caldenhof (2023) observe that economic security has become an increasingly important dimension of state protection, particularly in light of new forms of international competition. Likewise, Wigell et al. (2022) emphasize the importance of resilience mechanisms capable of mitigating vulnerabilities during periods of heightened geoeconomic instability. Dorneles, Ventura, and Almeida

(2021) further highlight the central role of the Brazilian state in designing policies aimed at the strategic management of natural resources.

According to the Energy Research Office (EPE, 2025b), Brazil's strategic integration into the new global order requires not only energy generation capacity but also the adaptation of national infrastructure to emerging demands, including the expansion of data centers driven by artificial intelligence applications. These developments will require robust electricity connections, expanded transmission networks, and enhanced storage capacity to ensure the efficient integration of variable renewable energy sources. Therefore, securing a prominent position within the new global energy order will require coordinated efforts involving state planning, technological innovation, environmental sustainability, and the strengthening of domestic productive chains. From this perspective, the green economy represents a viable pathway for integrating economic growth, social inclusion, and environmental conservation, as argued by CGEE (2012) and Sousa (2023), provided that Brazil's strategic resources are incorporated into a long-term development strategy aligned with ongoing transformations in the global energy sector.

IV. Final Considerations

The intensification of the global energy transition has promoted profound transformations in contemporary economic, productive, technological, and geopolitical dynamics. In this context, the growing demand for renewable energy sources and strategic minerals required for the manufacture of low-carbon technologies has increased the relevance of discussions concerning the geoeconomics of the energy transition and the geopolitics of strategic resources. For Brazil, a country endowed with significant mineral resources, extensive energy diversity, and a high share of renewable sources within its electricity matrix, understanding these transformations has become particularly important for the formulation of strategies capable of reconciling economic competitiveness, national sovereignty, and sustainable development. Therefore, this study has contributed to a broader understanding of the challenges and opportunities associated with Brazil's integration into the new international energy landscape.

The findings indicate that all proposed objectives were fully achieved. The general objective was accomplished through the analysis of the relationships between the geoeconomics of the energy transition and the geopolitics of strategic resources, identifying their implications for sustainable development in Brazil amid global energy transformations. Likewise, the specific objectives were fulfilled by examining the foundations of the geoeconomics of the energy transition and its repercussions for productive and technological systems; analyzing the geopolitical relevance of strategic resources and critical minerals for the global energy transition; investigating the impacts of these transformations on Brazil's prospects for sustainable development; and assessing the country's strategic role within the new global energy order based on its comparative advantages and productive capabilities.

The analysis developed in Section 3.1 demonstrated that the energy transition extends beyond environmental concerns and constitutes a process of international economic reorganization characterized by the reconfiguration of global production chains, the incorporation of new technologies, and the growing importance of sectors associated with decarbonization. The findings highlighted that geoeconomics has assumed an increasingly significant role in shaping national strategies aimed at enhancing competitiveness, economic security, and industrial capacities linked to renewable energy and emerging technological sectors.

With regard to Section 3.2, it was observed that critical minerals have assumed a central position in contemporary geopolitical disputes due to their importance for the production of batteries, electric vehicles, energy storage systems, electronic equipment, and renewable energy technologies. The analysis demonstrated that the geographic concentration of reserves and processing capacities has intensified concerns related to energy security and the stability of global supply chains, reinforcing the strategic dimension of natural resources within the international arena.

In Section 3.3, it was found that the availability of strategic resources and the expansion of the green economy may generate significant opportunities for sustainable development in Brazil. However, challenges were also identified regarding value addition, industrialization, natural resource governance, technological innovation, and the equitable distribution of economic benefits derived from mineral and energy exploitation. The results suggest that transforming natural resources into sustainable development depends upon the articulation of long-term industrial, technological, environmental, and educational policies.

Regarding Section 3.4, the findings indicate that Brazil occupies a privileged position within the new global energy order due to its extensive availability of renewable energy sources, the presence of strategic minerals, and its capacity to participate in productive chains associated with the energy transition. Nevertheless, the study demonstrated that the consolidation of this leadership position will depend on increased investments in science, technology, infrastructure, industrial innovation, and workforce qualification, as well as the development of strategies capable of promoting greater national participation in the higher value-added segments of the global economy.

Based on the evidence presented, future research is recommended to investigate the economic impacts of critical mineral industrialization in Brazil, the country's strategies for integration into global value chains associated with the energy transition, governance mechanisms aimed at the sustainable exploitation of strategic resources, and the socio-environmental implications resulting from the expansion of mining activities linked to the low-carbon economy. Comparative studies involving international experiences in value addition to mineral and energy resources are also highly relevant, as are prospective analyses concerning Brazil's positioning in relation to the geopolitical and technological transformations anticipated in the coming decades.

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