The Extractive Industries and Society 24 (2025) 101723

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Original article

The relaunching of industrial policy in Brazil: What have rare earths got to do with it?

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ARTICLE INFO

Keywords:
Rare earths
Strategic and critical minerals
Industrial policy
Neo-industrialization
Brazil
Mining

ABSTRACT

With the purpose of reverting the process of premature 'de-industrialization' suffered by the Brazilian economy in the previous decade, the Lula III administration has embarked on implementing a new industrial programme using a 'mission-driven' design. Several of the missions prioritised by *Nova Indústria Brasil*, officially announced in January 2024, will imply a greater demand for rare earths and other critical minerals necessary both for the energy and digital transitions, and the defence industry –integral components of the 'neoindustrialisation' objectives contemplated in the missions to be accomplished. Furthermore, in a setting of global great power rivalry and exacerbated supply chain failures, the quest for securing access to critical minerals away from China is offering Brazil, a country with large reserves of rare earths, additional prospects for linking production of these minerals to industrial policy. But how is the Federal Government responding to this opportunity for economic upgrading in its rare earths sector? The question will be examined by comparing Brazil's attempts at strategic management of rare earths over the 2010–2025 period within the context of President Rousseff's *Plano Brasil Maior*, the absence of industrial policy during the Temer and Bolsonaro administrations, and the recently launched *Nova Indústria Brasil*.

1. Introduction

Brazil is often signalled as representative of the revival of industrial policy in the Global South. However, past industrial plans implemented by successive *Workers' Party* administrations between 2003–2014, did not bring about the desired outcomes in terms of value creation, development of production networks, and promotion of new technology-intensive economic activities (Guimarães, 2021). In contrast, following a commodities boom led by agriculture and oil, economic downturn, protracted political instability, and the effects of the Covid-19 pandemic, there are signs of premature 'de-industrialization' in the country. Primary products expanded their share of exported value from 17 % in 1990 to 45 % in 2020, whilst manufacturing represented only 11.9 % of GDP (down from a 21.4 % peak in 1976) with dependence on industrial imports surpassing 90 %, thereby bringing into question the likelihood of Brazil's deeper integration into global manufacturing chains (De Toni, 2024).

The return of Luiz Inácio 'Lula' da Silva to power in January 2023 resumed a pro-active stance regarding industrial policy, with the 'energy transition' taking centre-stage. In a setting of global great power rivalry and exacerbated supply chain failures, the quest for securing access to critical minerals away from China and building resilience in global production networks is offering Brazil, a country with large reserves of rare earths elements (REE), fresh opportunities to strategically link extraction of these minerals to industrial policy.[1] Growing demand for rare earth-based materials and intermediate goods used in wind turbines and electric engines, among many other industrial applications essential to the 'green transition', could drive integration into global production

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[1] According to the U.S. Geological Survey (USGS), Brazil's rare earths reserves are estimated at 21 million metric tonnes (23.3% of world reserves), second only to China (44 million MT). Source: USGS, Mineral Commodity Summaries, January 2025. https://pubs.usgs.gov/periodicals/mcs2025/mcs2025-rare-earths.pdf (2 May 2025).

https://doi.org/10.1016/j.exis.2025.101723
Received 26 October 2024; Received in revised form 10 May 2025; Accepted 27 June 2025
Available online 3 July 2025

chains.[2] But how is the Federal Government responding to this opportunity to avoid a mere (new) 'commodities boom' lacking value aggregation domestically? I will analyse this question by comparing Brazil's attempts at the strategic management of rare earths between 2010–2025 within the context of President Rousseff's *Plano Brasil Maior* (PBM), the absence of industrial policy during the Temer and Bolsonaro administrations, and the 'mission-oriented' *Nova Indústria Brasil* (NIB) plan launched by the Lula III administration in January 2024. The underlying hypothesis in the analysis of each of these periods being that the degree of assertiveness with which the federal government was willing and capable of providing support for REE value chain development as part of its industrial strategy constitutes a crucial factor for the evolution of the sector.

2. The 'long road' to strategic management of rare earths in Brazil

Unlike China, where rare earths have been firmly on the policy agenda across decades, either as raw materials for defence technology (1950s-1970s), an important source of foreign exchange earnings (1980s-1990s) or 'industrial vitamins' –as REE are usually referred to in this country in connection with the development of high-tech final products (early 2000s-onwards), the strategic management of rare earths in Brazil has followed a patchy road. Geopolitical assertiveness has allegedly been at the core of the process that drove China to global domination of REE value chains –a process facilitated by domestic cheap labour and production costs, relaxed environmental standards, and central government steering (Abraham, 2015; Kalantzakos, 2017; Kiggins, 2015; Pitron, 2022). However, contemporary discussions about the advantages that these critical minerals may confer in great power conflict have been challenged more recently, suggesting REE policymaking in China follows a 'middle course' reflecting also domestic priorities regarding resource management, thereby shaping Chinese industrial policy and public-private articulation of REE production (Andersson, 2020; Duan, 2022; Shen et al., 2020).

In Brazil, on the other hand, after several decades of protracted neglect in policy circles, rare earths strategic management and their potential for industrial upgrading became part of the Federal Government policy agenda only in the 2010s (Melo, 2017; Santos and Loureiro, 2016; Sousa Filho and Serra, 2014) Having been the world's lead producer until World War I, Brazil remained a suppliers of rare earths minerals thereafter, even managing to export REE concentrates and pure oxides through the early 1970s. Brazilian scientists at the University of Sao Paulo (USP) and in the private sector (e.g., ORQUIMA S.A.) achieved proficiency in REE separation and oxide production from 'monazite'.[3] Nevertheless, despite the positive prospects for development, within two decades Brazil would lose the technological edge which it briefly enjoyed.

Stricter Federal Government control of radioactive materials introduced by the military regime's nuclear programme initiated in the mid-1960s increased the cost of handling monazite, discouraging REE production.[4] Ultimately, the establishment of a public monopoly over radioactive elements led to nationalization and downsizing of monazite processing (Lima, 2012).[5] Nor did these regulations result in government policies for rare earths strategic management linked to industrial policy. Consequently, development of the REE value chain was effectively truncated, in what constituted a process of 'technological obsolescence' (Sousa Filho and Serra, 2014). On the other hand, China's cheaper REE production started to flood international markets, driving prices down and competitors out of business. By the 1990s, when REE began to gain greater significance because of their use in new technological applications (i.e., magnets, electronics, telecommunications, etc.), Brazil was no longer competitive in the sector.

Not all previous technological development and human resources were wasted, nonetheless. The Brazilian scientific and academic community enthusiastically carried on debates regarding various aspects of REE research and processing.[6] It was precisely an initiative emerged from an academic meeting that brought rare earths to the radar of politicians during the last year of Lula's second term in office. The 'Commission for the Resumption of Rare Earth Production' established during the '4th National Meeting on Rare Earths', held in Aracaju (Sergipe), on 9 April 2010, delivered an 'open letter' on behalf of meeting participants to then Minister of Science and Technology, Sérgio Machado Resende, alerting about the importance of REE as essential inputs for various segments of Brazilian industrial production. Yet the country was completely dependent on imports from China whilst ironically, holding enough reserves to meet national demand.[7]

Premonitorily, in their April 2010 letter, Brazilian scientists also observed a tangible 'supply risk' considering that China was responsible for 95 % of rare earths global production at the time, and had begun restricting exports of REE products –first implementing export quotas in 1998, then banning concentrates exports in 2005 (Morrison and Tang, 2012; Yang, 2024). Beijing would further cut REE exports quotas by 40 % sending international prices soaring, whilst subsidising REE prices domestically purportedly to benefit local emerging high-tech industries. Letter signatories also noted that China's actions affecting global trade of rare earths products had already prompted industrialized nations to restart REE mining activities domestically or to look for alternative sources abroad. Within this geopolitical context, scientists strongly urged the Federal Government to adopt policies supporting resumption of national production and promoting value aggregation along the REE supply chain to at least meet domestic market needs.

The creation in June 2010 of an 'Interministerial Working Group on

[2] The 17 elements collectively known as 'rare earths' have gained prominence in recent decades due to their unique magnetic, superconductive, luminescent, catalytic, and metallurgical properties. REE are used in the production of permanent magnets, catalysts, fuel cells, wind turbines, hybrid/electric vehicles (EVs), solar panels, semiconductors, energy-saving lightning, mobile phones, laptops, TV sets, etc., as well as having other numerous industrial applications (i.e., glass, ceramics, phosphors, etc.) The defence industry also uses REE in a wide range of technologies from control systems and precision-guidance for weapons and missiles, to drones, jet engines, radar, sonar, night-vision and stealth technologies, among others.

[3] By the 1960s, rare earths research had spread to several innovation 'nodes' across the country, including the 'Institute of Energy and Nuclear Research' (IPEN) and research centres at various universities (UNESP-Araraquara, USP-Ribeirão Preto, UFC-Fortaleza and UFPE-Recife) (Sousa Filho & Serra, 2014).

[4] Thorium, and to a lesser extent uranium, are radioactive elements usually found in association to monazite.

[5] ORQUIMA S.A. became state-owned 'Monazite Production Administration' (APM), then *Nuclebrás Monazita* (NUCLEMON), and more recently the 'Brazilian Nuclear Industries' (*Indústrias Nucleares do Brasil*–INB).

[6] The Federal University of Pernambuco (UFPE) organized the 'First National Meeting on Rare Earths' (*Encontro Nacional de Terras Raras-ENTR*), in Recife (PE) in 1994. The State University of São Paulo (UNESP) hosted the second and third meetings in Araraquara (SP), in 1995 and 2003, respectively. In 2010, it was the turn of the Federal University of Sergipe (UFS), followed in 2012 by the fifth edition hosted by the Federal University of Paraíba (UFPB) in João Pessoa (PB). The final meeting of this series was held again in Recife, convened by the UFPE in 2014 (Melo, 2017).

[7] Letter signatories specifically noted that Brazil's industries used REE in catalysts for petroleum cracking, high-performance magnets and batteries for electric/hybrid vehicle engines and wind power generators, lighting systems, contrast agents for medical imaging, and new technologies like photonics and molecular electronics (Santos & Loureiro, 2016). Scientists also noted that Brazil was not only rich in minerals containing rare earths but had been a main producer, accumulating important technological knowledge in the field until the 1960s.

Strategic Minerals' (GTI-ME) was a direct consequence of the 'Letter of Aracaju'. The GTI-ME was composed by representatives from various departments of the Ministry of Mines and Energy (MME) and the Ministry of Science, Technology and Innovation (MCTI).[8] The Working Group prioritized the analysis of rare earths and lithium, as well as the expansion of financial resources destined to support RD&I in areas of geology, mining, mineral transformation and value addition along production chains. After various meetings with experts engaged in these activities, including the 'Centre for Mineral Technology' (CETEM/MCTI) and the 'Brazilian Nuclear Industries' (INB/CNEN/MCTI), among others, in December 2010 the GTI-ME issued a final report recommending that REE be the focus of a priority and immediate federal programme.[9] Six specific proposals were advanced: (i) establishing a government coordination instance, (ii) commissioning prospective studies, (iii) conducting geological surveys, (iv) identifying domestic demand and integrating ongoing projects, (v) funding and implementing RD&I programmes in mineral technology and transformation, and (vi) promoting public-private partnerships. It was also underlined that articulation of existing competencies and alignment of research and resources dispersed across the nuclear sector, the military, universities, private corporations and public research and innovation funding agencies would be required to develop necessary skills and regain lost technological capabilities.

GTI-ME proposals were carried into the Dilma Rousseff administration (2011–2016), generating impacts on several Federal Government policy domains, including mining, science and technology and industrial policies. Indeed, the 'National Mining Plan 2030′ (PNM-2030), released in February 2011 by the MME, explicitly signalled the adequate management of critical minerals as one of its goals. Both GTI-ME and PNM 2030 timely overlapped in their final deliberations during the second semester of 2010 and shared the same definition of 'strategic minerals' classified in three categories.[10] Unlike critically assessments in other countries, this classification fell short of offering quantitative calculations or a detailed list of the minerals officially considered 'strategic' –the initially preferred term used in Brazil to refer to what is called 'critical minerals' elsewhere. Despite nuances between both terms, throughout this text they will be used interchangeable.[11] Nevertheless, concrete actions contemplated in PNM 2030 regarding critical minerals management evidenced remarkable close alignment with GTI-ME recommendations.[12] GTI-ME's recommendations also informed objectives and actions of the 'National Strategy for Science, Technology and Innovation' (ENCTI 2012–2015) elaborated by the MCTI and made public at the beginning of 2012. Close interaction with the MME during GTI-ME proceedings resulted in agreement to promote sustainability and competitiveness of critical minerals production chains as part of the strategy. However, although included in ENCTI's technological development and innovation plans regarding energy and mineral resources, critical minerals as a whole failed to reach priority programme status, being placed among the 'complementary' endeavours contemplated by the newly announced science and technology strategy.

Subsequent actions pursued by the MCTI mobilized crucial resources and capabilities facilitating the creation of synergies between various institutions. For example, commissioned in 2011 by the 'Secretariat of Technological Development and Innovation' (SETEC/MCTI) and coordinated by the 'Centre for Management and Strategic Studies' (CGEE/MCTI), the prospective study 'Uses and Applications of Rare Earths in Brazil: 2012–2030′ paved the way for the articulation of a REE industrial development programme.[13] The CGEE study, published in June 2013, evaluated two prospective scenarios with horizons until 2020 and 2030, envisioning the achievement of technological mastery, self-sufficiency and sustainable competitive insertion in REE international markets. These scenarios were used as reference for the design of 'strategic roadmaps' for the five REE production chains identified as most significant in the short-medium term, which the study recommended prioritising as part of the country's ongoing industrial policy.[14] The study also

[8] Namely, the Secretariat of Geology, Mining and Mineral Transformation (SGM/MME); the Department of Technology and Mineral Transformation (DTTM/MME); the Secretariat of Technological Development and Innovation (SETEC/MCTI); the General Coordination of Sectoral Technologies (CGTS/SETEC/MCTI) and the Centre for Mineral Technology (CETEM/MCTI). GTI-ME was created by Interministerial Ordinance nº 614/2010 (30 June 2010).

[9] Other institutions involved in these discussions were the National Nuclear Energy Commission (CNEN/MCTI); Ministry of the Environment (MMA); National Department of Mineral Production (DNPM/MME); Mineral Resources Research Company (CPRM/MME); Federal University of Pernambuco (UFPE); Federal University of Goiás (UFG); Federal University of Santa Catarina (UFSC); University of Brasília (UnB); and University of São Paulo (USP) (BRASIL, 2010).

[10] These categories referred to (i) minerals imported on a large scale or susceptible of experiencing importation shortages, some of them crucial for agrobusiness interests (e.g., potassium, phosphate, metallurgical minerals, coal, uranium); (ii) minerals whose demand is increasing and expected to expand in coming decades due to their use in high-tech products (e.g., rare-earths, lithium, tantalum, cobalt); (iii) minerals providing Brazil comparative advantages and global production leadership (e.g., iron ore, niobium) (BRASIL, 2011).

[11] The European Union (EU) maintains a list of 'critical minerals' (CRM) since 2010. The EU list includes raw materials subject to high supply risk and considered of great importance for the European economy. Similarly, the U.S. Department of the Interior (USDOI) classifies minerals as 'critical' on grounds of economic and national security and based on criticality assessments provided by experts in academia and industry (Machacek, 2017). China's first official raw materials criticality assessment was released in 2016 (Andersson, 2020).

[12] It should be noted that, in parallel to the PNM-2030 announcement, the MME continued work on a draft bill to update the legal institutional framework for management of mineral assets in Brazil. It was expected that reforms to the Mining Code of 1967 would facilitate the design of specific policies for 'strategic minerals' to guarantee accomplishment of PNM-2030 actions. After several delays, in June 2013, PL5807/2013 was finally forwarded to the National Congress for consideration 'on an urgent basis.' Nevertheless, despite being at an advanced stage of discussions, and having received many amendments, it was never voted by the Chamber of Deputies (Dias & Frattari, 2020). Besides proposals to modernize procedures for the granting of mining rights and introducing changes to the calculation of mining royalties (CFEM), the aspect of PL 5807/2013 that would have had an important impact on the management of critical minerals refers to changes in governance mechanisms. Indeed, the bill instituted the 'National Council for Mineral Policy' (CNPM), an advisory instance of the highest status for the design of public policies for the mining sector, and the National Mining Agency (ANM) as the regulatory body for the sector. However, both the CNPM and ANM would have to wait several years to be formally created.

[13] In addition to CGEE, CETEM/MCTI and SETEC/MCTI, the project 'technical team' benefited from collaboration of SGM/MME, IPEN/CNEN/MCTI, CENPES/PETROBRAS, IPT, EQ/UFRJ, UFSC, and several other public and private stakeholders invited to participate in working meetings (Santos & Loureiro, 2016).

[14] The production chains identified were (i) permanent magnets, (ii) catalysts, (iii) metal alloys, (iv) phosphors and powders for polishing, and (v) manufacturing of glass and special lenses.

identified relevant public and private institutions as potential partners and suggested strategic actions for their articulation (CGEE, 2013b).[15] Later in 2013, SETEC/MCTI commissioned a follow-up techno-economic study from CGEE, which proposed 'action plans' for the promotion of investments and innovation necessary to develop technological and entrepreneurial competences in prioritized REE production chains (CGEE, 2013a, 2014). The resulting 'Rare Earths Elements Brazil Project' (ETR-BR) constituted the embryo of a larger REE programme that would be formally incorporated into Brazil's ongoing industrial policy.

3. Adding 'industrial vitamins': connecting rare earths to industrial policy

The *Plano Brasil Maior* (PBM), an immediate follow-up to the industrial plans implemented under the Lula I and II administrations (2003–2010), was launched in August 2011 with the objective of strengthening the domestic productive and technological structures of the Brazilian industry with a view to adding value and expanding markets. To achieve these goals, PBM envisioned the implementation of a series of sectoral measures to promote innovation, increase competitiveness, and articulate initiatives between public and private stakeholders. The 'structural' dimension of the plan was formed by guidelines to articulate horizontal ('systemic') policies with vertical ('sectoral') actions (Kupfer et al., 2013; Mattos, 2013; Silva, 2021; Stein and Júnior, 2016). Those guidelines involved measures to develop new technological and business competencies and strengthening and integrating domestic production chains. The PBM singled out nineteen sectors for economic upgrading organized into 'blocks' according to production processes and value chain configurations involved. Industrial mining and metallurgy were included in 'block 2' corresponding to large-scale, intensive production systems (ABDI, 2014).[16]

The original PBM strategic agenda for mining and metallurgy did not include rare earths among the industrial promotion actions considered for these sectors. However, following progress made by MME and MCTI initiatives, particularly regarding REE geological mapping and expansion of reserves, and the development of prospective studies for REE value chain development, these minerals eventually became part of the 'strategic agenda' of the PBM 'Mining Industry Executive Committee' in connection with objectives of the 'Multiannual Plan 2012–2015′ (*Plano Plurianual*–PPA).[17] The 'Rare Earths Elements Brazil Programme' (ETR-BR Programme) was formally incorporated into industrial policy actions in September 2013. In fact, this late addition to *Plano Brasil Maior* (PBM) represented the materialization of recommendations made by the GTI-ME in December 2010. The 'ETR-BR Programme' aimed at implementing a fully integrated REE production chain. Specific objectives of the programme included building business synergies between REE production segments to attract private investments, accelerating development and adoption of REE technological applications, increasing reserves and reducing dependence on imports of REE products (CEDES, 2014; Santos and Loureiro, 2016: 27–28).[18]

In terms of 'ETR-BR Programme' governance, a 'Working Group' integrated by the MME, MCTI, MDIC, CGEE, CETEM, CPRM, DNPM, plus the 'Brazilian Agency for Industrial Development' (ABDI) and the 'Brazilian Development Bank' (*Banco Nacional de Desenvolvimento Econômico e Social*–BNDES) was established in December 2013 with the objective of setting up medium- and long-term directives. The CGEE/MCTI assumed executive coordination functions with the mission of structuring a competitive production chain of REE permanent magnets within a five-year horizon (BRASIL, 2015, 2016). CGEE/MCTI was supported by a 'technological consortium' formed by CETEM, IPT, UFSC and CERTI, as well as national and international consultants. Also established in December 2013, the 'Monitoring Commission for the Rare Earth Elements Programme' (*Comissão de Acompanhamento do Programa de Elementos Terras Raras*–CAPETR) hosted meetings and discussions throughout 2014 to form partnerships with the business sector and obtain support and financing for programme development. Engagement efforts led by ABDI played an important part in articulating the 'ETR-BR Programme', particularly regarding BNDES participation and bringing together the government, academic and private sectors.

Entrepreneurial engagement involved key strategic partners identified at this stage, namely large mining companies such as CBMM (*Companhia Brasileira de Metalurgia e Mineração*), Taboca (MINSUR), Vale, and manufactures of final goods using REE processed products like WEG (electric engines and equipment), *Fábrica Carioca de Catalisadores S.A.* (FCC), MBAC (fertilizers), and Bosch, among others. Of particular importance, CBMM and WEG –two high-tech Brazilian multinationals– would have been pivotal to function as 'anchors' for value chain development in upstream and downstream stages, respectively.[19] CBMM is the leading world supplier of niobium products with operations fully integrated from mine extraction to niobium-processed materials widely used in iron and steel production. From niobium tailings it is possible to extract rare earths, to which additional processes of 'separation' and 'oxide production' could be added. On the other hand, WEG specialises in electric engineering, power and automation technologies. One of the main inputs for several of the company's products (e.g., electric motors, generators, turbines) are 'permanent magnets' made with rare earths. Given the level of cutting-edge technological development achieved by both companies in their respective business areas, it was hoped that they could easily diversify into other nodes of the REE

[15] The CGEE study significantly expanded the scope of a previous project concluded in May 2011, coordinated by the CERTI Foundation in association with the Fraunhöfer Institute (IFAM). In fact, the 'Study for the implementation of a production chain of rare earth magnets in Brazil' had endorsed an initiative emanating from the involvement of the 'Brazilian Agency for Industrial Development' (ABDI) in bilateral cooperation meetings between the MDIC and the German Ministry of Education and Research (BMBF). The technical-economic feasibility report prepared by CERTI –with advice from CETEM–, characterized four major stages of the magnet production process (mining and concentration; solubilization and separation; reduction and preparation of alloys; and magnet manufacturing). It also identified likely private sector partners across production segments and foresaw the implementation of demonstration units and their industrial upgrade for rare earth magnets utilization in wind generators and electric/hybrid vehicles involving Brazilian and German companies (Santos & Loureiro, 2016).

[16] Other 'blocks' considered by PBM included mechanical, electronic and health systems; labour-intensive systems; agribusiness systems; and trade, logistics and services.

[17] The PPA is an instrument for medium-term planning that the Federal government utilizes to define guidelines, objectives, and funding of the public policies over a 4-year period.

[18] In addition to the 'ETR-BR Project' resulting from the CGEE/MCTI prospective study, three additional actions included in the 'ETR-BR Programme' deserve equal credit –two of them directly under MCTI's responsibility. The first one concerned resumption of government research in REE technological characterization, oxides production, and training of human resources, leading to the creation of 'PROTERRARAS' in August 2013. This 2-year project received R$2.0 million (US$0.35 million) from CT Mineral/MCTI/CNPq –a sectoral fund supporting research in mining and mineral technology, which is part of the 'National Fund for Scientific and Technological Development' (FNDCT) administered by the 'Funding Authority for Studies and Projects' (*Financiadora de Estudos e Projetos* –Finep). The second action supported REE industrial transformation processes, laboratorial infrastructure and promotion of international cooperation with R$9.0 million (US$1.6 million) research grants conferred between 2013-2016 (Melo, 2017). The third action referred to the geological mapping of strategic mineral occurrences on Brazilian soil to be carried out by the CPRM/MME, which later became the 'Geological Survey of Brazil' (SGB).

[19] The 'Workshop on Integration of the REE Production Chain' hosted in Araxá (Minas Gerais) by CBMM on 20-21 November 2014 was an important example of efforts to engage the private sector in the 'ETR-BR Programme'.

value chain. However, despite becoming involved in several government-funded research projects –with active participation of the academic and scientific community– to develop new REE-related technologies, neither CBMM nor WEG ventured into vertical integration of these activities and have remained in their respective lines of business to the present day. Competition and predatory pricing from China, the absence of a domestic market for REE products, and the large amounts of financing needed were usually cited as reasons for these commercial decisions.

By December 2014, when *Plano Brasil Maior* came to an end, it was expected that the 'ETR-BR Programme' would be pursued in the next industrial policy cycle. Nevertheless, in the months leading to Rousseff's impeachment, industrial policy struggled to crystallize into a new plan, leaving the public agenda altogether after the abrupt end to Rousseff's second term in office (Machado, 2022). As a consequence, the 'ETR-BR Programme' was abandoned. The strategic management of rare earths resources lost the momentum it had enjoyed in federal policymaking during the first half of the 2010s and did not find continuity nor the same motivations under the Temer and Bolsonaro administrations (2016–2022).

Once again, the scientific and academic community with support from the MCTI, maintained alive the debate while making important contributions to research and technological development in the rare earths field. Indeed, another spinoff of GTI-ME recommendations had been the organization of the 'Brazilian Seminar on Rare Earths' (SBTR) congregating academia, government officials and the private sector in Rio de Janeiro in December 2011. A second edition of the seminar followed in November 2013. In a context of waning impetus for industrial policy and political turbulence at the federal level, the celebration of a third meeting in November 2015, hosted by CETEM/MCTI, was instrumental to support dialogue and interaction between stakeholders with the purpose of regaining government support at a later stage. These interactions continued along time, with the sixth and most recent edition of the Seminar being held at CETEM in November 2023.[20]

Meanwhile, despite the uncertainty about industrial policy, critical minerals stayed firmly on the radar of the MCTI, which called for the creation of a new 'Interministerial Working Group' focusing on rare earths production. The request was made during a meeting between representatives from MCTI, MME, MDIC and ABDI in September 2015. At the time, Alvaro Prata, Secretary of Technological Development and Innovation (MME), argued that "[Brazil] must fully master the rare earth production chain so that we do not sell the raw mineral, but rather the intermediate and final products, such as oxides, catalysts, alloys and permanent magnets." The idea was to generate momentum similar to that originated with the creation of the GTI-ME in 2010 following the 'Letter of Aracaju', which had led to the 'ETR-BR Programme'.[21] Although this new Working Group never materialized, in May 2016 the MCTI announced its 'National Strategy for Science, Technology and Innovation' (ENCTI 2016–2022). The updated strategy called for (i) elaboration of an action plan for strategic minerals; and (ii) the promotion of research, technological development and innovation to enable production of final goods using strategic minerals (De Castro et al., 2022).

Important initiatives regarding funding of specific RD&I projects for rare earths development also occurred against a backdrop of industrial policy vanishing. One such initiative was the establishment in 2015 of the 'National Institute of Science and Technology–Processing and Application of Rare Earth Magnets for High Technology Industry' (INCT-PATRIA). Coordinated by the IPT and the *Escola Politécnica/Universidade de São Paulo* (Poli-USP), this 'technological hub' was born out of articulations originally facilitated by the 'ETR-BR Programme'. The network intended to integrate scientific knowledge dispersed across different institutions and served as liaison with companies interested in the rare earths business, including REE processing, and manufacturing of permanent magnets and high-performance motors and generators. Each institution/laboratory within INCT-PATRIA was responsible for developing different projects linked to its specific area of expertise. Besides UFSC, CETEM and IPEN, companies like CBMM and WEG were also engaged in this network focusing on the development of technologies for production of REE oxides and alloys, and wind generators and electric motors using REE magnets, respectively.

On the financing end, in May 2016 the BNDES and the 'Funding Authority for Studies and Projects' (Finep) announced the 'Inova Mineral' programme, a joint initiative to promote investment plans in five 'thematic lines' for technological development in mineral transformation and their production chains, one of which was 'strategic minerals'. Following two rounds of public calls, R$ 1.18 billion (approximately US$200 million) were made available to fund selected projects, including five proposals in the 'strategic minerals' thematic line (two focusing on rare earths), which represented 26 % of selected projects and the second most competitive line with 11 proposals submitted. However, given lack of continuity, this initiative has been characterized as ephemeral and poorly structured due to its failure to amalgamate other policies, namely the PNM-2030 or ENCTI 2016–2022 (Holanda, 2023; Pope and Smith, 2023).

All things considered, the 2010–2016 period saw the rise and fall of strategic management of rare earths in Brazil, from the 'Letter of Aracaju' to the creation of the GTI-ME and the ETR-Programme, to paralysis following the end of PBM in December 2014. Progress was indeed made when REE became part of the federal government's policy agenda, and the economic upgrading of the sector was supported by state agency as part of the ongoing industrial programme. However, in an environment of growing uncertainty regarding continuity of industrial policy, which carried into the Temer administration (2016–2018), federal government's willingness and capacity to support further development of the REE sector also waned. Temer's most important action regarding mining was perhaps the establishment of the 'National Mining Agency' (ANM) created by Provisional Measure No. 791 (MP 791/17), eventually transformed into Law (No. 13,540/2017). But numerous amendments meant that the regulatory agency's attributions and competences were curtailed from what was originally envisioned in the Mining Code Reform bill of 2013 (PL 5.807/2013, articles 23 to 34) –never approved in Congress. Meanwhile, the same academic and scientific community that promoted the 'Letter of Aracaju' –with strong backing from the Centre for Mineral Technology' (CETEM/MCTI)– helped keep the debate on the strategic importance of rare earths alive, whilst the 'Innova Mineral' programme –which received funding from the BNDES/Finep– enabled various research activities for the development of technologies necessary for later expansion of the REE value chain in the country. However, given the limited scale and scope of these efforts, and in the absence of state agency as part of industrial policy goals and plans, they would not be sufficient to entice the business sector to commit the level of investments needed to complete the missing production nodes and verticalize the REE value chain in Brazil.

4. Critical minerals management in an industrial policy void

Since its inauguration in January 2019 the Bolsonaro administration

[20] Poli/USP-IPT (Sao Paulo, October 2017) and the 'Centre for the Development of Nuclear Technology' (CDTN) in Belo Horizonte (April 2021) organized the fourth and fifth editions of the SBTR, respectively. A 'Workshop on Rare Earths' was also organized by CETEM in Brasilia in October 2019.

[21] In attendance to this meeting were the Secretary of Technological Development and Innovation (MME), Alvaro Prata; the Secretary of Geology and Mining of the Ministry of Mines and Energy (SGM/MME), Vicente Lobo; the Secretary of Industrial Development and Competitiveness of the Ministry of Industry, Foreign Trade and Services (MDIC), Igor Calvet; the Director of the Mineral Technology Centre (CETEM), Fernando Lins; and representatives of the Brazilian Agency for Industrial Development (ABDI). https://boletim.sbq.org.br/noticias/2016/n2555.php (17 October 2024)

embraced a liberal stance regarding the economy, with no place for industrial policy on the agenda. In this respect, this represented the continuation of President Temer's abandonment of a 'developmental' role for the state. Nevertheless, Bolsonaro went further than his predecessor by dismantling the MDIC altogether, some of its functions (i.e., international trade) being subsumed by the newly created 'mega' Ministry of Economy –which also engulfed the *Ministério da Fazenda*. Similarly, both ABDI and BNDES acquired a much lower profile during his administration, effectively restraining –or eliminating, in the case of MDIC– the power and influence that these three key federal government institutions had exercised as driving forces behind the formulation and implementation of past industrial plans.[22]

In the absence of industrial policy, it is paradoxical that Bolsonaro, not without controversy, resumed attempts at critical minerals management, with active involvement of the MME. Indeed, Presidential Decree n° 10.657 of 24 March 2021 instituted the 'Pro-Strategic Minerals Policy" (*Pró-Minerais Estratégicos*) and created an 'Interministerial Committee for Analysis of Strategic Minerals Projects' (CTAPME) to 'support' the environmental licensing of projects for the production of critical minerals, with the purpose of accelerating processing of mining licenses applications. The novelty was its linkage to the 'Investment Partnerships Programme' (PPI), created by Law n° 13.334/2016 and run by the 'Civil House' (*Casa Civil*) to promote public-private partnerships which were treated as undertakings of 'strategic interest' and 'national priority'[23] CTAPME, coordinated by the MME, became responsible for assessing and granting approval to new research and extraction projects based on criteria reflecting the three 'categories' of strategic minerals defined in PNM-2030. Also, filling an important gap, the new policy drafted for the first time an official list of 28 minerals considered 'strategic' for Brazil, which CTAPME would be responsible to update on a regular basis (Resolution n° 2 SGM/MME, 18 June 2021) (De Castro et al., 2022).

Notwithstanding its purported objectives, government actions and public declarations evidenced an 'extractivist' rather than 'strategic' view in connection with *Pró-Minerais Estratégicos*, which some analysts have equalled to the promotion of a 'regime of exception' for mining activities to benefit entrepreneurial interests (Milanez et al., 2022).. For example, based on data published in CTAPME's annual report for 2023, out of 19 projects approved since its inception, valued at R$68 billion, the great majority (63 %) were related to minerals generating an important surplus in the country's trade balance –with iron ore and copper leading the way, and destined to export markets without processing. Meanwhile, minerals associated with the energy transition or used in high-tech applications, and those in which Brazil is highly dependent on imports, represented 21 % and 16 %, respectively. Thus, generating speculation about the existence of a 'commercial' bias in the implementation of this policy (IBRAM, 2024). It should also be said that none of the projects approved by CTAPME concerned new REE mining or comprised plans for value aggregation before export.

The 'Pro-Strategic Minerals' policy has been defended on grounds that its ultimate objective was to help businesses navigate bureaucratic obstacles, synchronizing procedures, and facilitating verifications and public consultations both at federal and sub-federal (state) level. However, the policy has also been seen as a vehicle to circumvent environmental, indigenous, urban, water and cultural heritage protection aspects in the name of the 'national interest' –which procedures followed to approve some projects deemed 'strategic' seem to confirm (Milanez, 2021; Pope and Smith, 2023; Wanderley et al., 2020). Linked to this, Bolsonaro usually employed niobium as an argument to defend mining in protected areas in the Amazon region.[24] Nevertheless, opening the Amazon region would also have important implications for future REE production in Brazil. For example, *Seis Lagos*, a protected biological and indigenous reserve in the state of Amazonas, is home to a polymetallic deposit containing large reserves of niobium, manganese, and rare earths.[25] Equally contested was the issuance of Decree n° 11.120 of 5 July 2022, which allowed foreign trade operations of lithium and their derivatives without authorization of the 'National Commission for Nuclear Energy' (CNEN), as required before given its status as mineral of interest for nuclear energy under state monopoly.[26] Despite accusations of benefitting multinational corporations in lithium mining, and fears of promoting accelerated mineral extraction with negative environmental consequences, reproducing commodity export schemes without domestic value aggregation, this norm opened the door for the adoption of similar regulations regarding the management of monazite minerals containing REE in association with radioactive substances.[27]

Decree n° 11.108 of 30 June 2022, which instituted the 'Brazilian Mineral Policy' (*Política Mineral Brasileira*–PMB) and created the 'National Council for Mineral Policy' (CNPM), also deserves special mention. Allegedly conceived with the mission to formulate, coordinate, and articulate plans, programmes, and actions of the Federal Government for the development of the mining sector, and drive further improvement of regulatory and governance aspects, the decree limited itself to listing generic and often difficult to reconcile principles for policymaking.[28] On the other hand, returning to one of the proposals included in the Mining Code reform bill of June 2013 (PL 5.807/2013), the newly-created CNPM –advising directly the President of the Republic– would assume responsibility for determining PMB priorities, planning instruments and specific programmes –including critical minerals or the 'National Mining Plan' (PNM), for example.[29] Nevertheless,

[22] Namely, the 'Industrial, Technological, and Foreign Trade Policy'–PITCE (*Política Industrial, Tecnológica e de Comércio Exterior*, 2003-2008), the 'Productive Development Plan'–PDP (*Plano de Desenvolvimento Produtivo*, 2008-2010) and the 'Greater Brazil Programme'–PBM (*Plano Brasil Maior*, 2011-2014).

[23] The 'Civil House' assists the President of the Republic in the administration of other federal bodies and provides advice on political and institutional relations. Casa Civil is also responsible for coordinating, articulating and monitoring public policies for infrastructure (e.g., *Novo PAC*) and projects considered strategic for the national interest.

[24] In fact, mining authorizations for niobium exploration more than doubled during his administration, experiencing a 156% increase in the Amazon region alone, allegedly without consulting local indigenous populations, as reported by *Unidades de Conservação no Brasil* (https://uc.socioambiental.org/pt-br/noticia/215644) and *Folha de São Paulo* (https://www1.folha.uol.com.br/ambiente/2022/02/sob-bolsonaro-autorizacoes-para-exploracao-de-niobio-explodem-na-amazonia.shtml) (16 October 2024).

[25] Similarly, Mineração Taboca –owned at the time by the Peruvian mining group Minsur– operating the Pitinga mine (located also in the state of Amazonas, but not within a protected area), expected to produce rare earths in addition to tin extraction (its main operation in the site). Reportedly, Taboca dumped mining waste into Pitinga's adjacent rivers creating environmental concerns for nearby indigenous populations in the Waimiri Atroari territory. https://dialogue.earth/en/pollution/51271-brazil-mining-expand-indigenous-territories/ (16 October 2024)

[26] https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2022/decreto/d11120.htm and https://www.bnamericas.com/en/news/brazil-publishes-decree-to-boost-lithium-segment (15 October 2024)

[27] http://emdefesadosterritorios.org/decreto-de-bolsonaro-promove-abertura-para-exploracao-do-litio-e-permite-que-multinacionais-explorem-regioes-ja-empobrecidas-pelos-processos-historicos-de-mineracao-como-o-vale-do-jequitinhonha-em-m/ (16 October 2024)

[28] Maximizing the socioeconomic benefits of mining, preserving the national interest, sustainable development, socio-environmental responsibility, value aggregation, economic diversification, promoting free markets, and respect for human rights, are cited –among others– as guiding principles.

[29] As pointed out by (IBRAM, 2024)., although the PMB focuses on mining activity in general and Decree 11.108 does not contain specific references to critical minerals, the CNPM could signal a priority status for these minerals and/or rare earths, in particular.

the composition of the Council was contested from the beginning and the CNPM never met.[30]

As before, the MCTI carried on work following guidelines established by ENCTI 2016–2022, and released its 'Action Plan for Science, Technology, and Innovation for Strategic Minerals 2018–2022' (*Plano de Ciência, Tecnologia e Inovação para Minerais Estratégicos*). The plan intended to identify main technological challenges for the integral development of production chains of prioritized critical minerals. Based on GTI-ME final report recommendations, the CGEE prospective studies, and assuming prerogatives of the 'ETR-BR Programme', REE actions considered by the plan included expanding the activities of science and technological centres (ICTs) and promoting RD&I projects for REE permanent magnets manufacturing on a pilot and industrial scale; expanding support for REE projects within the scope of the Brazil-Germany bilateral cooperation; and creating a Working Group for planning, coordination, integration, monitoring, and evaluation of projects and activities for development of the REE production chain.[31] Implementation would be done with financial resources from the 'National Fund for Scientific and Technological Development' (FNDCT/MCTI), the 'Technological Fund' (FUNTEC/BNDES), the 'Brazilian Company for Industrial Research and Innovation' (EMBRAPII), as well as potential new editions of the 'Inova Mineral' (Finep/BNDES).[32]

Similarly, following Decree n° 10.746 of 9 July 2021, which instituted the 'Policy for Science, Technology and Innovation in Advanced Materials,' and in accordance with ENCTI 2016–2022, the MCTI released its 'Plan for Science, Technology and Innovation in Advanced Materials'.[33] Among the plan's initiatives, a technological hub focused on graphene, niobium and rare earths (GraNioTer) was established to support strategic projects that have already attained early stages of technological maturity. GraNioTer's objective was to prospect stakeholders and investors, promote synergies and establish strategic partnerships to 'thicken' the value chain of those materials. The hub is headquartered at the 'Centre for the Development of Nuclear Technology' (CDTN) on the campus of the Federal University of Minas Gerais (UFMG) and is financially supported by Finep.

According to US Geological Service (USGS) data, REE mine production in Brazil throughout 2010–2022 represented less than 1 % of world production.[34] In the years after the introduction of the 'ETR-Programme' (2013), REE mine production saw an increase from null in 2014 to 1700 tonnes in 2017 (1,27 % of world total), only to decline steadily to 80 tonnes in 2022 (0.03 %). These numbers seemingly speak of a 'minor' player in the field –particular in comparison to China, whose share in REE mine production oscillated between 70 % to 85 % during the same years. Similarly, REE mineral transformation (e.g., separation, oxide production) and production of REE-based intermediate goods (e.g., permanent magnets), despite advances at research and technology development level, did not materialise. Yet, when looking at REE reserves throughout this period there is indeed a 'big jump' in Brazil's worldwide share from less than 1 % (as consistently reported by USGS between 1994–2012) to 16.9 % in 2013, peaking at 19 % in 2022. One of the components of the 'ETR-BR Programme', following GTI-ME report recommendations, had been to expand 'geological mapping' of critical minerals. Work of the 'Brazilian Geological Service' (CPRM/SGB) enabled the growth of estimated REE mineral reserves from 40 thousand tonnes to 22 million tonnes by end-2014 (BRASIL, 2015); (BRASIL, 2016; Santos and Loureiro, 2016). This explains the dramatic change almost overnight when USGS reports updated their data using information provided by CPRM/SGB. It should be observed though that REE reserves estimates have stayed at the same level since 2013, and that recent changes in Brazil's share of worldwide reserves are only explained by USGS adjustments (usually reductions) to estimations for other countries as no new REE reserves for Brazil have been added.[35]

In sum, despite the announcement of new policies regarding critical minerals, the fate of rare earths production and processing in Brazil remained largely uncertain, whilst the motives behind *Pró-Minerais Estratégicos* were highly questioned. The Inova Mineral programme was not extended beyond 2017. ABDI and BNDES/Finep policy instruments were severely curtailed – not to mention the dismantling of the Ministry for Industrial Development (MDCI). In the absence of industrial policy, the long-awaited creation of the 'National Council for Mineral Policy' (CNPM) did not bring continuity to federal programmes for REE development. Instead, its non-installation generated an institutional vacuum, filled by the promulgation of 'Presidential decrees'. Meanwhile, progress made in REE technological research –with limited public funding available and the enthusiastic participation of the REE academic and scientific community– did not find echo in private sector investments for production of rare earth-based materials and intermediate goods. Arguably, the most tangible achievement of attempts at REE strategic management introduced by various administrations throughout the 2010–2022 period was the significant increase registered in REE estimated reserves. Certainly not an inconsequential event, which –given the size of existing deposits– have placed Brazil again as a potential important player in REE global markets.

5. The return of industrial policy: the Lula III administration and rare earths

With the purpose of reverting the process of premature 'de-industrialization' suffered in the previous decade, one of the major goals of the Lula III administration was to formulate a new industrial plan based on consensus with the private sector and civil society, international best practices and insights from Brazil's own past experience. The policy of 'neoindustrialization', as it became known in the official narrative, was to be constructed using a 'mission-driven' design, identifying problems

[30] In addition to 12 representatives of the Federal Government, rather than being chosen by their peers, controversially all other members (including representatives of states, municipalities, civil society, and higher education institutions) would be appointed by the MME. Criticism was also raised given its lack of popular consultation mechanisms, the main argument being that any grand mineral policy should not be the product of non-elected technocrats, but instead approved by Congress following a broad debate with the population. Exercising deliberative or normative functions, as intended by Decree 11.108, would also expose the Council to lobbying pressure from powerful groups (Milanez et al., 2022).

[31] A project implemented within the context of technical cooperation with Germany that deserves mentioning is the 'REGINA Project' (Rare Earth Global Industry and New Applications). Originally launched in August 2017, REGINA received EUR 2.8 million in funding to support industrial implementation of REE value chain nodes from rare earths oxides to magnets production. Brazilian partners involved in this project included UFSC, USP, CERTI, CETEM, CBMM, and WEG S.A.

[32] Embrapii (*Empresa Brasileira de Pesquisa e Inovação Industrial*) is a federal agency established in 2013, which supports companies' technological research. It does not finance basic research or the finished product, but the manufacturing process. Embrapii may participate financially up to a third of total investment and brings with it a network of accredited research institutions –which contribute another third of project investments. The other third is to be committed by companies themselves.

[33] https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/Decreto/D10746.htm

[34] https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information (4 May 2025)

[35] It should be noted that these reserves correspond basically to REE 'monazite' deposits. The recent discovery of large REE 'ionic clays' deposits by private mining companies like Serra Verde, Meteoric and Aclara, among others, will significantly raise the country's estimated reserves (yet to be accounted by USGS), whilst making competition with China possible due to REE ionic clays extraction lower production costs. https://www.mining.com/meteoric-resources-takes-crown-for-worlds-largest-clay-hosted-rare-earths-project/ (7 May 2025).

to guide innovation strategy across various segments of the Brazilian economy, instead of choosing specific sectors as done before. Following a logic of multi- and inter-institutional task forces covering entire value chains, from basic and applied research to front-end industrial applications, the idea was to promote horizontal collaboration between sectors, rather than only focusing on vertical policies. The objective being not just to address market failures, but also to create new markets (De Toni, 2024; Mazzucato, 2018) As put by Vice-President Alckmin during his investiture discourse, "(…) Geopolitical disputes and changes in global value chains can represent an opportunity for Brazil to attract productive investments and increase industrial exports." (Alckmin, 2023) Alckmin –who also heads the 're-instated' Ministry of Industrial Development (MDIC)– hinted thereby to the government's awareness of potential economic upgrading options related to supply chain resilience, a propitious context where REE, and critical minerals more broadly, could acquire a priority status not enjoyed in past industrial plans.

The new industrial strategy also attempted to create an adequate degree of institutionalization and governance, whilst allowing flexibility to generate political consensus on 'missions' to be pursued combining a top-down approach with grassroots proposals. To this end, in February 2023 the 'National Council for Industrial Development' (originally established in 2004) resumed deliberative functions as a collegiate body composed of 20 ministries, the BNDES, and 21 representatives of civil society.[36] After extensive meetings between government and the productive sectors, the 'New Industry Brazil' (*Nova Indústria Brasil*–NIB) was announced on 22 January 2024. The 'neoindustrialization' strategy singled out six missions to be achieved, namely: (1) sustainable and digital agro-industrial production chains for food and energy security; (2) a resilient health-industrial economic complex; (3) sustainable infrastructure, sanitation, housing and mobility for productive integration; (4) digital transformation of industry to increase productivity; (5) decarbonization, bioeconomy, and energy transition; and (6) technologies relevant for national sovereignty and defence.

NIB implementation is to be financed through the 'More Production Plan' (*Mais Produção Plan*–known as *P* + *P*), which at the time of NIB launching earmarked R$300 billion (approximately US$50 billion) for project development until 2026 with resources managed by the BNDES (RS$250 bn), Finep and EMBRAPII.[37] Nonetheless, funds allocation depends on prior identification of production chains for each of the six missions, and more importantly, on the initiative of the private sector and companies seeking financing and submitting projects for approval. Assessment and determination are being done based on mission objectives, market opportunities, economic complexity, existing local capacities, potential for high-tech exports and generation of qualified jobs, and transversal impacts across the economy. This process is still ongoing and taking longer than desirable given the 4-year term of Brazilian electoral cycles.

According to NIB's Action Plan 2024–2026, it is expected that several 'industrial niches' will be developed in connection with the digital and energy transitions, and the defence sector. Developing production chains for semiconductors, equipment for the generation of renewable energy, communications and sensing systems, and autonomous and remotely controlled vehicles will require an increased use of critical minerals. However, there is only a handful of references to these resources throughout the 100-pages Action Plan's full text, whilst 'rare earths' are mentioned just once referring to the automotive sector, electric motors and permanent magnets in relation to Mission 3 (mobility). Intriguingly, the MEM and MCTI are omitted as 'responsible' for this production chain, assigned to the Ministries of Industry, *Fazenda*, and Education. Similarly, despite listing the development of equipment to generate renewable energy (Mission 5), the NIB Action Plan does not make an explicit link to rare earths –an important component in wind turbines and also used in fuel cells and solar panels. Nor are REE referred to in connection with technological applications in the defence industrial base (Mission 6) (BRASIL, 2024).

In general terms, strategic minerals and rare earths are not an 'agglutinating' feature of the NIB Action Plan, and its proper articulation into specific production chains is yet to be seen. As the main NIB governance instance, the CNDI has the challenge to coordinate the interests and priorities of various ministries, particularly the MDIC, MME, and MCTI, whilst engaging others, as the Ministry of Defence (MD), that could have an important say regarding choices in connection with Mission 6 specifically. Despite wide-ranging debates held within the CNDI, neither the MME, MCTI or the MD –the instances more knowledgeable with the potential of rare earths for industrial applications and which could have a bigger stake in production chains using critical minerals– seem to have an equal stance compared to the MDIC, *Fazenda* or the BNDES regarding decision-making and policy implementation.

Another issue that should be noted is that *Nova Indústria Brasil* (NIB) –led by MDIC and strongly backed by the BNDES, is just one among various initiatives in the Lula III administration policy mix.[38] Given its direct impact over economic growth and employment, NIB has received much more media attention. Less visible to the public eye, other initiatives have essentially been the result of 'in-house' policymaking without involving much participation of government officials from other ministries or deliberations encapsulating the consensus of a broad, representative constituency like the CNDI. Among these, the 'Ecological Transformation Plan' (PTE), announced in September 2023 and led by Ministry of Finance, stands out given its overhauling scope virtually encompassing NIB and other policies.[39] PTE also creates overlaps regarding specific actions for the energy transition, technological development, and circular economy objectives, all of which involve strategic minerals at some extent. Effective governance mechanisms, and articulation of programmes will be imperative for the success of the

[36] These included the 'National Confederation of Industry' (CNI), the 'Brazilian Mining Institute' (IBRAM), the 'Institute of Studies for Industrial Development' (IEDI), associations from various productive sectors (i.e., automotive, agribusiness, chemicals, semiconductors, construction, steel, etc.), labour unions, and Embraer, among others. Additionally, 16 other institutions, companies and think tanks were invited to participate in CNDI meetings, but without the right to vote –including Petrobras, Gerdau S.A., IPEA, FIESP.

[37] The P + P is organized into four major areas: (i) 'More Innovation', R$66 billion; (ii) 'Greener Industry', R$12 billion; (iii) 'More Exporting Industry', R $40 billion; and (iv) 'More Productive Industry', R$182 billion. During the second semester of 2024 P + P funding was increased to R$506.7 billion (almost US$90 billion), with a raise in budget for Finep credit and entry of other financing banks such as BNB, BB, BASA and Caixa. https://www.bndes.gov.br/wps/portal/site/home/transparencia/estatisticas-desempenho/painel-plano-mais-producao (2 May 2025)

[38] Major policy initiatives announced since January 2023 include: (i) the 'Ecological Transformation Plan' (*Plano de Transformacao Ecologica*–PTE) led by Ministry of Finance (*Fazenda*) with a focus on the 'green transition'; (ii) the 'New Growth Acceleration Programme' (*Novo Programa de Aceleração do Crescimento*–Novo PAC) led by Office of the Presidency (*Casa Civil*) with a focus on sustainable infrastructure supporting other government programmes; (iii) the 'National Plan on Climate Change 2024–2035' *(Plano Clima)* led by Ministry of the Environment (MMA); and (iv) the new 'National Strategy for Science, Technology and Innovation (*Estratégia Nacional de Ciência, Tecnologia e Inovação 2024-2030*–ENCTI) led by MCTI, currently under elaboration.

[39] PTE was officially launched on 1 December 2023 by the Minister of Finance (*Fazenda*), Fernando Haddad, at the UN Climate Change Conference (COP28) in Dubai, UAE. With the purpose of adopting a more sustainable development model in Brazil, and with the State acting as "facilitator", the PTE aims to stimulate investments in infrastructure, clean energy and electric mobility, among other actions contemplated. The plan is organized into six axes, including sustainable financing, technological development, bioeconomy, energy transition, circular economy and adaptation to climate change. PTE is also seen as a diplomatic engagement instrument to reposition Brazil as a flagbearer of the Global South at the centre of international discussions about the "green transition", environmental sustainability and social inclusion.

policy mix as a whole.

Timing and signalling of priorities have also played a part. For example, the 'More Innovation' programme has allocated R$66 billion until end-2026 to finance companies' technological innovation projects aligned with NIB.[40] 'More Innovation' was launched in December 2023, before the announcement of NIB itself, but failed to include mining among the sectors considered in its first call for new research projects. Thereby, sending contradictory signals, considering that REE in particular need technology development to fill existing gaps in production chains. This omission also made clear that, in the future, strategic minerals projects will have to compete on equal terms for innovation funds with other industrial sectors to be prioritized by NIB missions. Similarly, in February 2024, only weeks after NIB was announced, the BNDES and the MME launched the 'Strategic Minerals Equity Investment Fund' (*Fundo de Investimento em Participações Minerais Estratégicos*–FIPME). The Fund expects to raise a minimum R$1 billion (approximately US$ 175 million) to be allocated to 15–20 junior and medium-sized companies for mineral research, exploration projects, and development of new mines.[41] However, FIPME focused exclusively on 'upstream' activities, not industrial transformation or value chain development for critical minerals. This would be rectified with the announcement in January 2025 of a BNDES-Finep joint public call for business plans (R$5 bn/US$ 850 million) to promote investments in RD&I and production capacity for critical minerals 'transformation' and product manufacturing for the energy transition.[42]

Critical minerals and rare earths have also been a topic on the radar of congresspeople and the private sector, both instances playing a pivotal role promoting debates on REE strategic management from which important proposals for public policy have emerged. In May 2024, the 'Parliamentary Front for Sustainable Mining' (FPMin), organized the 'Seminar on Mining for the Energy Transition'.[43] The event gathered public sector representatives to assess how Brazil was reacting to increased global demand for REE and other critical minerals, bearing in mind that the country holds considerable reserves of several of these minerals. Similarly, in June 2024, the 'Brazilian Mining Institute' (IBRAM) –considered the spokesperson of the mining sector bringing together more than 130 members and all major mining companies in Brazil–, organized the 'Seminar on Critical and Strategic Minerals'. On the occasion, IBRAM released the 350-page report 'Foundations for Public Policies on Critical and Strategic Minerals for Brazil' elaborated in partnership with CETEM/MCTI.[44], Taking into account the reports' recommendations, a bill proposing the establishment of a 'National Policy on Critical and Strategic Minerals' (PNMCE) and the 'Committee on Critical and Strategic Minerals' (CMCE) –which would be linked to the 'National Council for Mineral Policy' (CNPM)– was submitted jointly by several FPMin members and awaits regular legislative processing for approval (PL 2780/2024).[45][46]

Finally, also during the FPMin May 2024 seminar, Vitor Saback, Secretary of Geology, Mining and Mineral Processing, confirmed the MME continued working on the 'Minerals for Clean Energy Programme' (*Programa Minerais para Energia Limpa*–MEL) as originally announced by Minister Alexandre Silveira the previous February. This programme, adding to the policy mix, would have the dual purpose of expanding geological knowledge and mineral research whilst developing capabilities for critical minerals processing with a focus on the energy transition.[47] Comprising financing, subsidies, training, technology development, and international promotion, among other aspects, the MEL programme had not been officially launched as of April 2025. This delay runs in parallel with the protracted installation of the CNPM, whose composition was reformulated and expanded by Decree n° 11.419 of 24 February 2024, but which is yet to hold its inaugural session. A legacy of Bolsonaro administration, the Lula III administration

[40] Funded by Finep/FNDCT/MCTI, $16 billion (€ 2.5 billion) will be 'non-reimbursable' whilst the rest will be made available as loans at 4%, the lowest nominal interest rate in Brazilian history for innovation projects. Resource allocation will also be aligned with the "structural axes" of the 'ENCTI 2024-2030' (under elaboration by MCTI), which will promote national strategic programmes and projects, including mineral technology for critical minerals.

[41] In addition to commitments made by BNDES and Vale (R$250 million each), it is expected that initial contributions from other institutions in the financial sector could reach R$3 billion. FIPME is one of the few investment funds of its type globally. According to Ore Investments and JGP BB Assets, which were designated as managing consortium for the fund, FIPME will have a maturity of 10 years. In line with other natural resources investment funds in mining, a return of 20% to 25% per year is forecast, considering the associated risks of doing business in Brazil in the mining sector. https://www.brasilmineral.com.br/noticias/fundo-proposto-pelo-bndes-podera-ter-aportes-de-r-3-bilhoes (21 October 2024)

[42] Following the 30 April 2025 deadline for applications for the BNDES/Finep public call, a total of 124 business plan proposals representing potential investment of R$85.2 billion were received. Of these, among others, R$6.4 billion refer to technological development and R$67.8 billion to industrial scaling of projects. Greatest interest among proposals focused on four minerals: rare earths (27), lithium (25), copper (24) and graphite (20). http://www.finep.gov.br/noticias/todas-noticias/6955-edital-da-finep-com-o-bndes-tem-r-85-2-bi-em-propostas-para-transformacao-de-minerais-estrategicos (7 May 2025)

[43] The *Frente Parlamentar da Mineração Sustentável* (FPMin) is integrated by more than 200 members (including Deputies and Senators). Formed in March 2023, its purpose is to promote legislation to provide legal security to mining activities, strengthening regulatory and supervision bodies, and facilitating investments in research, technology, and innovation for sustainable mining.

[44] The report was sent to Congress and officially presented on 9 July 2024 during a joint session of the 'Special Commission for the Study, Evaluation and Monitoring of Initiatives and Measures Adopted for Energy Transition in Brazil' (CEENERG), chaired by Deputy Arnaldo Jardim, and the FPMin, chaired by Deputy Zé Silva.

[45] https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=2447259 (22 October 2024)

[46] This is not the first time the Brazilian Congress has tried to introduced legislation specifically focussing on rare earths. In April 2012, the 'Science, Technology and Innovation Committee' (CCT) in Congress debated the issue from a perspective of the national interest and geopolitical considerations. In May 2013, the CCT appointed a 'Temporary Subcommittee for the Elaboration of the Regulatory Framework for Rare Earth Mining in Brazil' (CCTSTTR) to support the drafting of legislative proposals for the sector. The sub-committee's final report (July 2013) called for the creation of a programme to support technological development of a REE production chain and suggested actions be incorporated as amendments to the Mining Code reform bill then under discussion (PL 5.807/2013). It is interesting to underline the tone of the CCTSTTR final report. The document refers to past 'missed opportunities' following decisions (or inaction, for that matter) regarding the development of nuclear technology in the 1970s-1980s, and rare earths in the 1980s-1990s –when REE technological leadership was lost to China due to restrictive public policies or the lack of policies at all. In 2013, building on the momentum generated by the 'Letter of Aracaju', the CCTSTTR already signalled geopolitical concerns deriving from Brazil's quasi total dependence on REE product imports for industrial use (Senado Federal, 2013a, 2013b). Given the obstacles PL 5.807/2013 encountered for approval, in December 2013, the CTT proposed a specific Bill to address the matter (PLS-529/2013) instituting a 'Support Programme for the Technological Development of Rare Earths Minerals and the Creation of a Production Chain' (PADETR). The Federal Senate approved this bill in December 2014, but the proposal remained blocked by the 'Finance and Taxation Committee' of the Chamber of Deputies after May 2017.

[47] On 21-22 February 2024, the MME hosted the "Seminar on Mining and Mineral Transformation of Strategic Minerals for the Energy Transition" where Minister MME engagement in the elaboration of the MEL programme, which should be launched shortly after. Two of the blocks in the seminar included discussion panels and presentations regarding "public policies and the supply of minerals for the energy transition" and "official support for the development of the strategic minerals processing industry." https://www.gov.br/mme/pt-br/assuntos/secretarias/geologia-mineracao-e-transformacao-mineral/seminario-sobre-mineracao-e-transformacao-mineral-de-minerais-estrategicos-para-a-transicao-energetica (21 October 2024)

has validated the CNPM alongside the 'Brazilian Mineral Policy' (PMB).[48]

All in all, despite the potential for articulating actions regarding critical minerals in connection with production chains prioritized to accomplish NIB missions, 'neoindustrialization' has not resulted in an overarching national policy for the strategic management of these minerals crucial for the energy transition and other high-tech industrial applications –including defence systems. As vertical integration policies share protagonism with the promotion of horizontal collaboration between sectors, the articulation of REE production chains within NIB will not be straightforward. Efforts will require effective governance and a greater deal of coordination with the private sector and among federal government initiatives than previously demanded by the short-lived 'ETR-BR Programme'. Despite delays, the new industrial policy is gradually making financing available for the production and processing of critical minerals in Brazil. As before, federal government priority signalling and the presence of industrial policy 'missions' have generated favourable conditions for REE sector development. However, as past experience demonstrates, private sector engagement and investment in verticalization of the REE value chain remain decisive factors, particularly where budgetary restraints and fragile institutional capacity –demanding a profound restructuring of the regulatory agency (ANM) and definition of a critical minerals policy, for example– may curtail federal government's direct participation in economic activities related to REE sector upgrading.

6. Conclusions

From the analysis of events since 2010, it appears that the presence of a fully-fledged industrial policy constitutes a more propitious environment for the strategic management of rare earths. However, placing these minerals on the industrial policy agenda –let alone their prioritization among other value chains– is not a straightforward process, evidencing power asymmetries between different federal government bodies. Both the Ministry of Science, Technology and Innovation (MCTI) and the Ministry of Mines and Energy (MME), for whom fostering REE production chains customarily has prominence in policymaking, struggle to bring the issue to the attention of the Ministry of Industrial Development (MDIC), the Ministry of Economy (*Fazenda*) or the BNDES –institutions which have traditionally designed and funded industrial policy in Brazil. Surprisingly, the Ministry of Defence (MD), for which REE should have a more conspicuous role given the industrial applications for defence systems and equipment they facilitate, have not manifested equal influence or interest in the issue, at least not publicly. Similarly, competing strategic priorities and policy initiatives with overlapping scopes and goals emanating from various ministries make necessary careful harmonization of the policy mix.

The 'Letter of Aracaju' (April 2010) started a process which eventually gathered momentum during the Dilma Rousseff's administration, bringing rare earths to the industrial policy agenda, and culminating in the incorporation of the 'ETR-BR Programme' into *Plano Brasil Maior*–PBM (September 2013). Despite the longer-term vision provided by industrial policy, events demonstrate that economic upgrading and engagement of the private sector in REE production chains take time to mature. Nor are these processes immune to disruption due to political instability or Presidential turnover, bringing to the forefront the question of policy continuity. In the absence of industrial policy, government actions involving critical minerals seem to have responded to short-term entrepreneurial interests and lobby pressures (as seen most notably during the Bolsonaro years), without focus on value aggregation or technological development and incurring the risk of replicating extractive and commodity export schemes. Nevertheless, throughout the whole period under analysis, the role of the academic and scientific community has been and continues to be instrumental, either alerting government about the need to resume REE production (based on geopolitical concerns and the national interest as expressed in the 'Letter of Aracaju'), creating spaces for policy discussion (e.g., organization of various rare earths seminars), pushing forward REE research and technology development (despite limited public funding), or keeping alive a sort of 'policy inertia' in parts of the state bureaucracy, namely within the MCTI, waiting for a window of opportunity for rare earths to re-enter the industrial policy agenda.

Nova Indústria Brasil (NIB) represents such opportunity, particularly due to its explicit linkage to the energy and digital transitions, where REE –among other critical minerals– are expected to play a significant role. However, unlike *Plano Brasil Maior's* sectoral approach, given the nature of its mission-oriented formulation, NIB's prioritization of production chains will require even greater coordination, not only among federal instances, but to leverage business sector investments –a tough endeavour as already shown by the 'ETR-BR Programme'. Notwithstanding articulation efforts led by ABDI, provision of incentives through credit and grants were not sufficient to entice the private sector to vertically integrate REE value chains back then. Additionally, power asymmetries between federal bodies and the influence of lobbies may still determine the omission of certain production chains or prioritization of technological routes not necessarily articulated around rare earths' industrial applications this time round. Delays in identifying production chains to achieve NIB missions' objectives seem symptomatic. Priority signalling and increased funding for critical minerals extraction and transformation provided by BNDES/Finep under NIB may help avoid these pitfalls. However, lack of a solid institutional framework and governance issues remain stumbling blocks for the future of the REE sector in Brazil, even in the presence of industrial policy.

Norms and regulations usually derive from public policies' objectives and guidelines. The mining and mineral transformation sectors are no exception, and both the 'National Mining Plan' (PNM-2030), and successive science and technological innovation strategies (ENCTI), within the remit of the MME and MCTI, respectively, have prompted such discussions. Debates about the need for a differentiated regulatory treatment for critical minerals and rare earths to attract investments and promote technological innovation remain a contested arena, usually framed within larger discussions regarding amendment of the Mining Code of 1967 still in force. As a consequence, the 'National Mining Agency' (ANM), the regulatory entity belatedly created by Presidential decree during the Temer administration, remains exceedingly fragile, lacking resources and in need of restructuring to perform its functions adequately – an indispensable condition for the smooth implementation of any mineral policy.

On the other hand, despite various 'policy' announcements, the country still lacks a 'national', seamlessly integrated policy to guide the strategic management of critical minerals in connection to NIB missions. Despite the official rhetoric, the absence of such a policy undermines effective sector governance and the credibility of potential REE value chain development as part of industrial policy. The 'National Council for Mineral Policy' (CNPM) –whose establishment was originally suggested in 2013 (PL 5807/2013) but only created in 2022 (Presidential Decree n° 11.108)– failed to assume the mission to formulate and articulate federal government actions and programmes in the mining sector, including critical mineral and rare earths. As an instance for interministerial policymaking coordination, the CNPM was intended to mirror the decisive role played by the 'National Council for Energy Policy' (CNPE) in the energy sector since 1997. However, as of April 2025, the CNPM remains inactive, and its fate unclear.

In view of this, the legislative proposal currently under debate in the Brazilian Congress (PL 2780/2024), submitted in August 2024 by the

[48] The CNPM would mirror the role of the 'National Council for Energy Policy' (CNPE) which has been in function since 1997 effectively guiding energy policymaking in Brazil, a sector comprising large and influential players like Petrobras and Eletrobras.

'Parliamentary Front for Sustainable Mining' (FPMin) –with strong support and in line with the interests of the mining private sector embodied by IBRAM– constitutes a step forward to remedy the above-mentioned deficiencies. Indeed, the definition of a national policy and governance mechanisms for the strategic management of critical minerals could finally enable the accomplishment of actions spelled out in both the PNM-2030 and science and technology strategies (ENCTI) in connection to critical minerals, going back to the 'Letter of Aracaju' and the formation of the GTI-ME interministerial working group. At a time of renewed interest in industrial policy and federal government commitment to decarbonization and the energy transition, the formulation of clear policies and determination of instruments and parameters for state agency in the area of critical minerals in connection with industrial policy and other policy domains, coupled with institutional strengthening of the mining sector, would greatly help entice business sector engagement and attract necessary investments to ultimately advance REE value chain development in Brazil. Nevertheless, given maturity times, volume of investments and commercial risks involved in REE production and transformation, compounded by doubts about policy continuity beyond 2026, direct involvement of the federal government in eventual REE private-public partnerships –at least in the initial stages– may be needed as an additional policy tool to secure private investors' sustained commitment to such projects.

CRediT authorship contribution statement

Manuel Mindreau: Writing – original draft, Investigation, Conceptualization.

Acknowledgements

This work is part of the author's PhD research at the International Institute of Social Studies (ISS), supported by the European Research Council (starting grant No. 950056).

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