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# New industrial policy for a new world: Seizing Brazil's opportunities in the energy transition

The world is rapidly transitioning to a new energy system and Brazil has a potential to be a great power in the emerging geopolitical order. It has the critical minerals, renewables resources, biocapacity, and manufacturing base to be a major producer and exporter of energy, materials, and technology. It has all the elements to lead in industries critical to the 2050 global green economy: transition metals, biofuels, low-carbon steel, wind manufacturing, and aviation manufacturing.

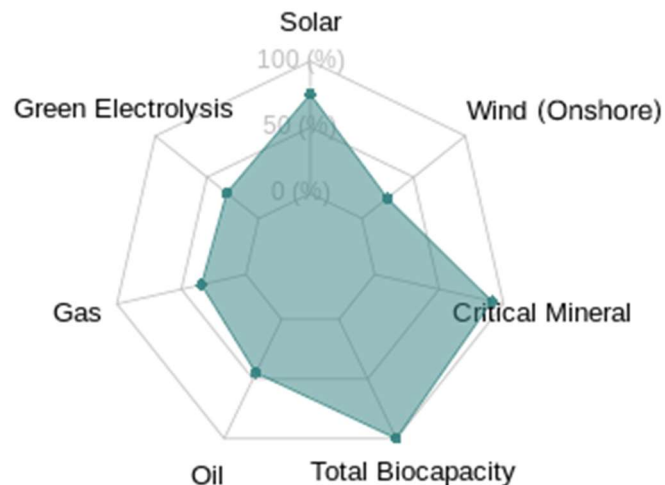
To seize these opportunities, Brazil has launched a new industrial policy, Nova Indústria Brasil (NIB). It is a promising venture that demonstrates a clear understanding of the contours of the emerging world order and Brazil's potential place in it. In this report, we analyse Brazil's position in the global market, its existing domestic production base, and NIB policy initiatives together with enterprise responses for seven priority sectors.

The new strategy suffers from three weaknesses. First, industrial policy works best when it targets specific subsectors or technology areas, where problems can be precisely and dynamically formulated and where all parts of society can work together to formulate solutions. The mission orientation of NIB is too broad to provide the necessary focus. This means that, second, NIB's allocated funds, amounting to roughly USD 60bn, are likely to be spread too thin across too many priorities to gain Brazil a foothold in highly competitive verticals. Third, it is unclear what the mechanisms of collaboration among government, firms, labor unions, civil society and independent experts will be. Another key lesson of industrial policy is that dynamic experimentation and interaction is needed, but there is no clear plan to create knowledge-based clusters and design sector specific policy mixes in Nova Indústria Brasil.

### Brazil's position in the new geopolitics

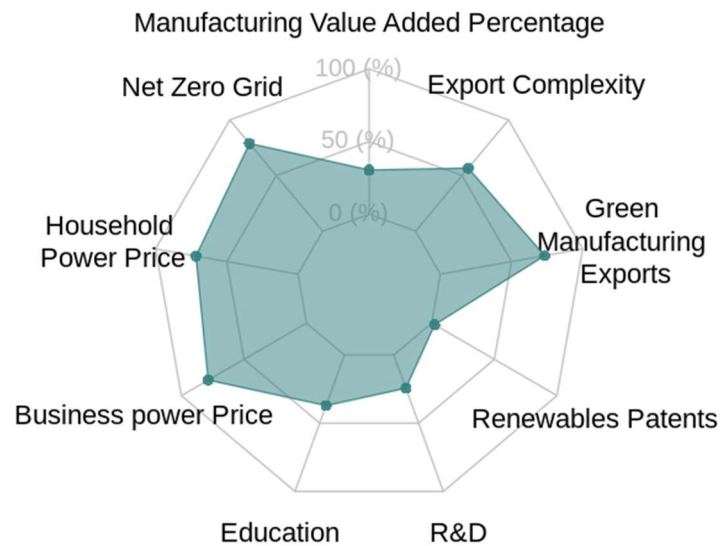
The energy transition is creating winners and losers.<sup>1</sup> In the new geopolitics, the countries that matter most possess leading solar and wind potential, critical minerals reserves, biomass resources, and hydrogen potential. Brazil's size and resource endowment gives it the potential to be a leading resource power. Combined with its capabilities in advanced manufacturing and mechanized agriculture, Brazil can be a first-rank power in the new energy system alongside China, United States, and Russia.<sup>2</sup> Brazil also holds significant oil & gas reserves and expertise, which can contribute during the transition, without a need for further expansion.

Figure 1. Brazil's natural resource potential for the new energy geopolitics



Source: NZIPL analysis.<sup>3</sup>

Figure 2. Brazil's advanced manufacturing potential in the new geopolitics



Source: NZIPL analysis.

Brazil has strong manufacturing potential. It already produces and exports complex manufacturing goods. It has a clean grid with competitive prices, providing a strong base for energy intensive industry. However, the country must invest in the research and innovation base as it lags behind its great power peers in R&D spending, education, and patents. Benchmarking to other emerging economies, it does well on these indicators.

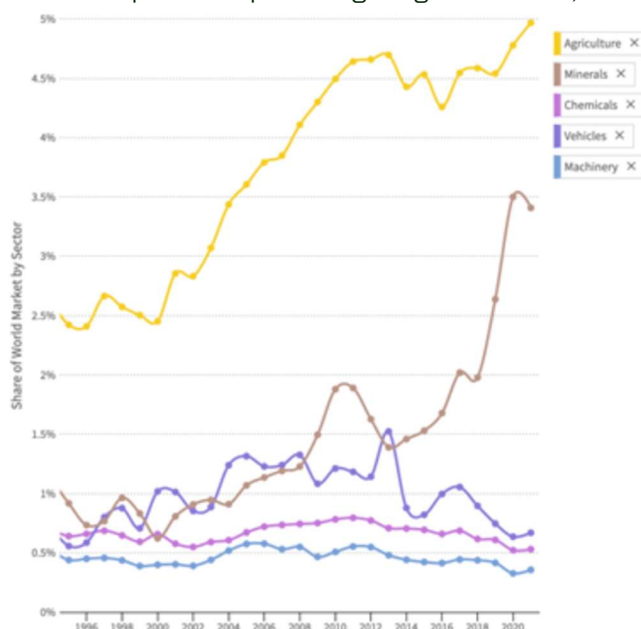
A key source of Brazil's advantage in manufacturing is the wide availability of cheap, clean electricity. This "powershoring" potential, where industries would relocate to an expanded Brazilian clean grid, positions the country well as a producer of energy intensive products in all sectors—particularly low-carbon steel, but also potentially direct lithium processing and machine manufacturing for the wind and battery supply chains. The country has additional advantages that are mapped and represented in Figures 1 and 2 above, but also a profusion of Development Financial Institutions that are key to finance projects for economic diversification.<sup>4</sup>

Brazil's manufacturing potential, however, must take Brazilian deindustrialization into account. Manufacturing represented 36% of Brazil's GDP in 1985 but fell to 13% in 2022.<sup>5</sup> This rapid decline in manufacturing was termed by many to be a case of premature deindustrialization: when a country transitions from a manufacturing-based economy to a services-based one before consumers have reached high income levels.<sup>6</sup>

Deindustrialization coincided with the rise of Chinese imports and the rapid growth of Brazilian agricultural exports. In effect, Brazil and China restructured their trade,

to the benefit of Chinese manufacturing.<sup>7</sup> China is Brazil's largest trading partner—representing 32% of exports and 23% of imports in 2021. The bilateral trade balance was in Brazil's favor by \$30.8bn in 2024, but this comes with trade-offs.<sup>8</sup>

Figure 3. Brazil's exports as a percentage of global market, 1995-2021



Source: Atlas of Economic Complexity

Brazil's exports of machinery, chemicals, and autos all rapidly declined after 2012—the year China and Brazil signed a “comprehensive strategic partnership.”<sup>9</sup> Meanwhile China invested in Brazil's agricultural and minerals sectors, which grew rapidly. In agriculture, some \$30bn in soybeans shipped from Brazil to China in 2021. That means soy alone represents 30% of Brazil's China exports and that trade alone constitutes almost 10% of Brazil's total exports. In minerals, China became a major consumer of Brazilian iron ore. Again, with \$33.4bn in imports in 2021, Iron ore represents 34% of the Brazil-China trade and 11% of all Brazilian exports. The number three export to China is crude oil (\$14.8bn), with the value-added refining step occurring in China, not in Brazil.<sup>10</sup>

Today, China is investing in Brazilian manufacturing with a series of BYD and GWM battery and EV plants and by expanding the world's top wind turbine maker Goldwind's footprint. This is needed investment which could, if strategically managed, help rebuild Brazil's manufacturing.

## Nova Indústria Brasil (NIB) policy overview

How can Brazil add value to its economy while building the resource and manufacturing base necessary to become a leading power? Brazil is currently making progress in achieving its green industrial potential through a variety of ministry-led transition plans. Out of the initiatives, Nova Indústria Brasil stands out as the clearest *Industrial Policy* plan, as it outlines interventions to incentivize production and investment in certain firms and sectors.

Table 1. Brazil's transition plans by different ministries that bear on green industrial policy

Transition Plan	
Ministry of Development, Industry and Commerce	Nova Indústria Brasil (NIB)
Ministry of Finance	Ecological Transformation Plan
Ministry of Mines and Energy	New Growth Acceleration Plan (Novo PAC)
Ministry of Environment and Climate Change	Climate Plan
Ministry of Planning	Plan 2050

Source: Brazil's Second Nationally Determined Contribution (NDC)<sup>11</sup>

Democratic industrial policies are not new in Brazil, as three major plans have preceded the NIB: the Industrial, Technological, and Foreign Trade Policy (PITCE 2004–2007), the Productive Development Program (PDP 2008–2010), and the Greater Brazil Plan (PBM 2011–2015). The first plan stood out for its sharper focus on innovation but was too small and underfunded to drive any meaningful shift in Brazil's productive structure. The broader sectoral focus of subsequent plans naturally brought allies to the process and increased the possibility for making strategic bets, but also led to a lack of focus, ultimately diluting their ability to challenge the country's persistently low economic complexity. These plans leaned heavily on sector-specific financing, reflecting a broader context in which governments lacked control over key macroeconomic variables—especially interest and exchange rates—and lacked the political power to drive major tax or regulatory changes. Despite recent strides in tax reform, after years of struggle, this structural limitation a pressing challenge today.<sup>12</sup>

Like its predecessors, especially the PDP and the PBM, the NIB opted for a broad foundational document. Its main innovation, however, was its focus on organizing sectors around missions, highlighting the inter-sectoral synergies required to

achieve them. The lack of detail on how to accomplish these missions drew immediate criticism.

Twelve months after its release, 5 out of the 6 missions outlined by the NIB had been officially launched by the end of 2024, with more details now publicly available. While all six missions have some relevance to decarbonization and green industrial policies, Missions 3 and 5 stand out as the most significant in this regard and will be the focus of this brief section.

Mission 3 focuses on infrastructure, encompassing initiatives related to electric vehicles and, by extension, battery development. Mission 5, explicitly dedicated to decarbonization, includes efforts targeting biofuels, wind and solar energy, and hard-to-abate sectors like steel and cement. The complementarity between these two missions is evident. For example, the government's large-scale infrastructure program, the new Programa de Aceleração do Crescimento (PAC), accounts for some of the investments in Mission 3 and could be leveraged to drive demand for solar panels and low-carbon steel and cement, aligning infrastructure development with sustainability goals.

The mapping of 'production chains' is underway for both missions. At the time of launching, Minister of Development, Industry, and Commerce (MDIC) Geraldo Alckmin presented three mapped chains for Mission 3, namely Propulsion Systems, Electric Batteries, and Metro-rail Transport.<sup>13</sup> The Minister's presentation also identified short-term goals for 2026, such as 2 million social housing units (500,000 of which will be equipped with solar panels) and 3% of the country's new vehicles electrified with nationally-built batteries. These numbers are targeted to scale up to 1.4 million social housing units with solar panels and 33% of new cars equipped with local batteries by 2033.<sup>14</sup>

For Mission 5, the minister presented biofuels (Green Diesel, SAF, and Ethanol), Green Hydrogen, Biomethane, Heavy Industry (Low-Carbon Steel and Cement), Wind Turbines, and Solar Panels as production chains of interest to Brazilian industrial policy. The goals presented for 2026 were modest and only included increasing the share of biofuels and electricity in the country's transportation matrix to 27%. This number is targeted to increase to 50% by 2033.<sup>15</sup>

In October 2024, the MDIC took another important step in detailing and monitoring its industrial policy, as it created a 'Working Group on Strengthening Priority Productive Chains for NIB Missions'. This seeks to operationalize broad plans and move towards quantitative criteria to inform more specific policies that can complement what is already being done.<sup>16</sup>

As with previous industrial policies, the Brazilian government has opted to establish sector-specific lines of credit, now organized under inter-sectoral missions. Building on this initial effort, the government has already pledged

funding for 2025 and 2026, providing crucial forward guidance to the private sector. For Mission 3, \$10.8 billion in new direct investments has been announced, alongside an additional \$48 billion in financing to drive demand in the construction sector. Mission 5 received a pledge of \$2.36 billion for key industries.

In addition to subsidized credit, the NIB's missions are complemented by measures, especially tax breaks and using the government's purchasing power to promote NIB priority sectors with preferential procurement processes favoring national products over imported ones. The creation of an Interministerial Commission on Public Procurement for Sustainable Development (CICS) was a major step forward, introducing preference margins for local products and those made with recycled materials. While margins have been set for vehicles and cement, steel remains excluded. A minor regulatory adjustment could extend these benefits to national steel, particularly greener options like biochar steel and Scrap-EAF steel.<sup>17</sup> In Mission 3, the Mover program stands out with a pledged total of \$3.2 billion in tax credits for automotive companies that comply with sustainability and innovation conditionalities. Given the history of sectoral policies in Brazil, it is no surprise that the most detailed conditionalities are now in the automotive sector.<sup>18</sup>

In Mission 5, non-financing initiatives have been shared with the Ministry of Mines and Energy and the Ministry of Environment and Climate Change. The *Fuel of the Future* program has created clear thresholds for the addition of biofuels to fuel mixes and for the decarbonization of air travel—although not clear consequences for non-compliance on the latter.<sup>19</sup> The government has passed the *Legal Framework for Low-Carbon Hydrogen*, creating a regulatory sandbox for the sector, establishing a special tax regime for its production and development—Rehidro and the Program for Development of Low-Carbon Hydrogen (PHBC).<sup>20</sup> These policies are key for sectors we evaluate in detail below—Low-Carbon Steel and Fertilizers.

The government has also reinforced that these public investments are there to induce private investment. As a result, it has disclosed significant private sector commitments: approximately \$176 billion for Mission 3 and \$63 billion for Mission 5. These figures underscore the strategic use of state funding as a catalyst for broader private sector participation.

Although there are promising initiatives in the current landscape of Brazilian industrial policy, the overreliance on funding means that current policies are not paying enough attention to coordination problems. Thus, true collaboration among government actors, businesses, unions, and other stakeholders has not properly materialized. This may be the reason most sectoral policy mixes have been underspecified. This problem can still be solved, but as the government advances into its second half, time is running out.<sup>21</sup>

## Brazil's top opportunities in the energy transition

Brazil can position itself in the industries of the future energy system by building on its strengths in agriculture and mining. However, its relatively weak manufacturing sectors need focused, targeted attention in order to realize their potential.

In this section, we present some key opportunities for Brazilian green industrial policy. These opportunities allow Brazil to capitalize on its world-leading natural resource base. For seven highly promising green industrial sectors, we analyze (1) the Brazilian position in the global competitive market landscape, (2) the existing domestic production base, and (3) the Brazilian policy initiatives and enterprise responses.

Our goal is to identify priority areas for future work on microtargeting, policy design, and institutional or process design. This could serve as an input for the working groups current operationalizing Brazilian industrial policy.

### Critical Minerals

Brazil is a mining powerhouse and is already a leader in many transition metals. It is the world's second-largest producer of iron ore and graphite as well as a major producer of bauxite (for aluminum) and manganese (Table 2). Because of its existing assets and expertise, Brazil has opportunities to develop a strong technological position across the entire transition metal productive chain: exploration and development, extraction, mine site processing, refining and tailings management, and recycling and reprocessing.<sup>22</sup>

Brazil has been touted for its lithium and nickel potential. The US Development Finance Corporation has invested in Brazilian nickel through its stake in Techmet, which opened the Piauí Mine in northeastern Brazil in 2022.<sup>23</sup> The mine has an annual production target of 25,000t of contained nickel by 2025.

The Minas Gerais region is home to promising lithium deposits currently under development. Canadian-listed Sigma Lithium's project in Grota do Cirilo contains an estimated 109 million tons of lithium.<sup>24</sup> Sigma has secured a letter of intent from BNDES to support an ambitious development plan that would expand production to 104,000t of lithium carbonate equivalent annually.<sup>25</sup>

These are important developments, but nickel and lithium prices have both been falling through 2023 and 2024. With Indonesian nickel and a variety of lithium projects coming online, the medium-term outlook for both metals is mixed. Without a broader critical minerals club that supports demand for new projects or provides some form of international price certainty, nickel and lithium projects will be difficult to fund.



Table 2. Brazil's transition metals

	Production 2023, t	Rank (share)	Reserves 2023, t	Rank (share)
Bauxite	31,000,000	4 (7.75%)	2,700,000,000	5 (9%)
Copper	410,276	13 (1.9%)	12,324,150	n/a (1.2%)
Cobalt	290	n/a (.13%)		10 (1%)
Graphite (natural)	73,000	4 (4.6%)	74,000,000	2 (26.4%)
Lithium	4,900	5 (2.7%)	390,000	7 (1.4%)
Iron ore	280,000,000	2 (18.6%)	15,000,000,000	2 (17%)
Manganese	620,000	6 (3.1%)	270,000,000	4 (14.2%)
Nickel	89,000	8 (2.5%)	16,000,000	3 (12.3%)
Silicon metal	200,000	2 (5.3%)	n/a	n/a
Tin	18,000	6/7 (6.2%)	420,000	5 (9.8%)
Titanium	n/a	n/a	3,160,591	n/a

Source: USGS 2024; S&P Market Monitor.<sup>26</sup>

In this context, focusing on graphite and manganese processing would add value to the Brazilian economy while helping partners de-risk supply chains. Several firms have taken an interest in getting Brazilian graphite into the battery supply chain.<sup>27</sup> Brazil is already a major producer of graphite. From a domestic perspective, adding processing steps to graphite production would add value to the commodity and build exports. Moreover, graphite is not as complex to produce as other battery components and so this should be achievable with existing knowledge and skills. From a global perspective, graphite is a high priority mineral for diversification and friendshoring because China dominates refined graphite production. It is one of the most valuable minerals to begin friendshoring.<sup>28</sup>

Manganese is a central component of the leading commercial cathodes. The amount of manganese needed for batteries is a small percentage of overall production, so no shortfalls in manganese are expected. Nonetheless, battery-grade manganese sulphate, a key cathode input, is projected to be in shortfall.<sup>29</sup> Manganese thus presents another opportunity for Brazil to add value to its existing resource base while supplying partners with critical transition metals.

Brazil has taken steps in its mining policy and has recently restructured its National Council for Mineral Policy (CNPM).<sup>30</sup> In partnership with the Ministry of Mines and Energy, the BNDES has also established a Critical Minerals Fund of approximately \$167 million to support start-ups and medium companies working on research and development, and on new mining enterprises.<sup>31</sup> In January 2025, an additional \$833 million in joint FINEP-BNDES funding was announced for

projects aimed at critical mineral transformation for the energy transition and decarbonization.<sup>32</sup>

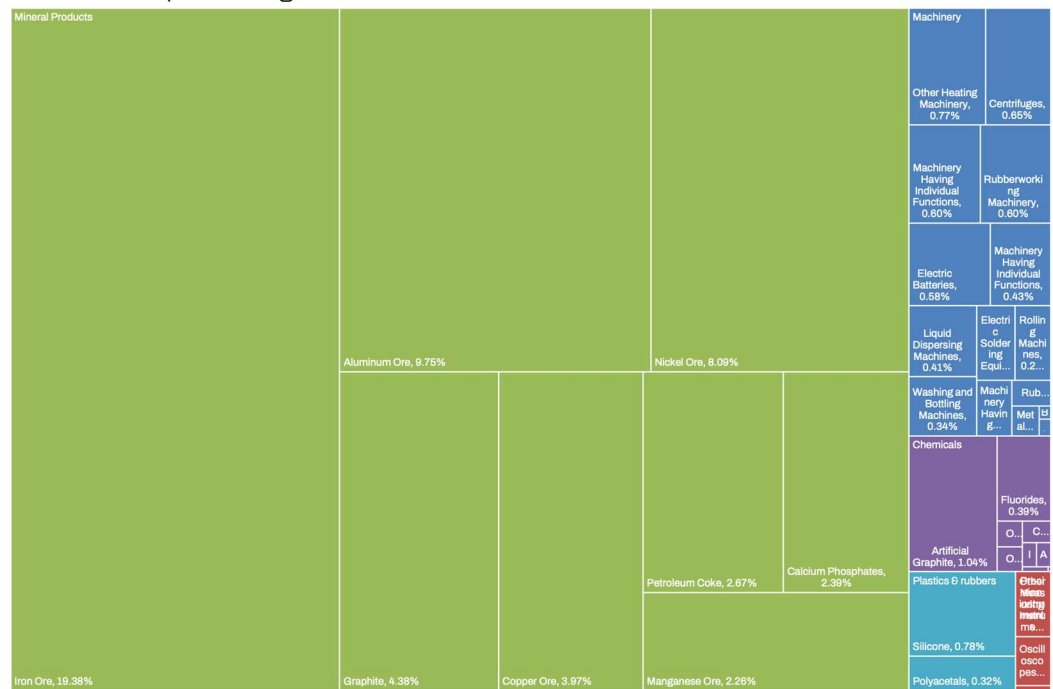
### Batteries and battery components

Brazil is also working to build its battery supply chain. The country has 15GW of battery production capacity, about 1.2% of global capacity in 2023. Most of this production is by BYD, which is building two factories at its site in Camaçari, Bahia. BYD is also planning e-bus manufacturing and lithium processing at this site. The third factory, in Manaus, Amazonas, produces lithium iron phosphate batteries, but the facility is still scaling production. BorgWarner, a US company headquartered in Michigan, also has a small 200MWh battery factory in São Paulo state targeting production for hybrid and electric vehicles. Inventus, which produces lithium-ion batteries for electronics, also has a small facility in Manaus.<sup>33</sup>

So, Brazil has a budding battery cluster. However, there is a danger that this industry will have little value-added. Global cell manufacturing is likely to be highly competitive due to overcapacity in the sector. Therefore, margins will be quite low in the final stage of assembly. The real value-added in the battery supply chain is in upstream mining and value-added processing. Thus, it is imperative that countries which seek to gain from battery production build upstream supply chains.<sup>34</sup>

While Brazil has strengths in critical minerals outlined above, it has no midstream assets in cathode material, anode material, separators, or membranes. The announced BYD lithium processing unit in Camaçari would be a foothold in these upstream value-added segments, but there is still a large structural hole in the supply chain. This presents an opportunity, especially in the case of anodes, where Brazil has existing strengths in artificial graphite and silicon processing.

Figure 4. Brazil's exports in the battery production and supply chain: strengths in upstream minerals and processing



Source: NZIPL analysis of UN Comtrade data.

However, the underlying industrial base for battery manufacturing in Brazil is weak compared to other emerging market economies. In battery production, it is the broader parts and machines ecosystem that provides the real economic benefits. Our analysis, see Figure 4, of Brazilian exports in these areas shows a structural weakness. Brazil is strong on the minerals needed for both nickel-rich and iron-phosphate cathodes, natural and synthetic graphite, and copper foil. It also has chemical expertise applicable to graphite and silicon anodes. These resources have strong potential to create value-added mining and processing. But Brazil lacks the machinery exports that would indicate strength in the production process. Typically, strong manufacturers also exhibit strength in the machinery and precision instruments sectors.

In terms of current policy, as outlined in Mission 3, the Mover program focuses on gradually increasing the share of domestically produced content in batteries, with the Brazilian government primarily leveraging the land transportation sector to boost battery production. In addition to performance-based tax breaks tied to electrification and decarbonization—designed to spur demand for electric vehicles—the government has raised import tariffs on electric vehicles and committed to gradually increasing them further to encourage domestic production.<sup>35</sup> In parallel, 2024 has already seen approximately \$140 million in

BNDES loans to support Volkswagen's production of hybrid and electric vehicles, with more large financing expected for the sector.<sup>36</sup>

So, policies for the sector exist, but Brazil will need to focus on creating the absorptive capacity for battery manufacturing if it wants to prevent a “battery enclave” wherein foreign companies produce batteries with foreign knowledge and foreign supply chains, creating little value-added in the Brazilian economy.

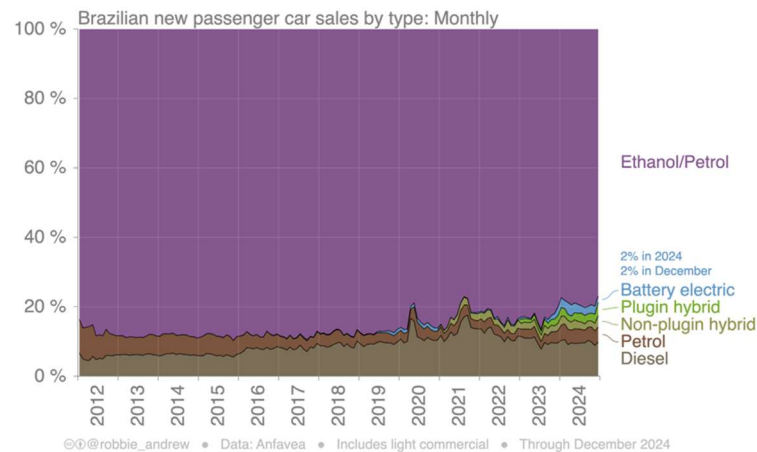
### Electric Vehicles and Ethanol-battery Hybrids

If Brazil can overcome its challenges and implement a robust policy mix for battery production, it could become a key player in the electric vehicle (EV) and hybrid vehicle markets. With the size of its internal market, its established automotive sector (which made Brazil the 8th largest producer of vehicles in 2022), and its clean energy matrix, the country is well-positioned to build a competitive EV sector. This potential is further supported by Brazil's long-standing tradition with biofuels—especially ethanol—and the growing market for ethanol plus battery or flex-fuel-hybrid vehicles.

In recent years, however, the outlook for Brazil's automotive industry appeared bleak. Major multinationals like Ford and Mercedes shut down their Brazilian operations, due to low profits and business restructuring.<sup>37</sup> The closures cast a shadow over the sector, raising concerns that other major players, such as GM, might follow suit.<sup>38</sup> Amid this uncertainty, Toyota bet on the introduction of its first imported flex-fuel hybrid engines to the Brazilian market, signaling a restrained confidence in the country's potential.<sup>39</sup> Still, the overall scenario looked dire.

Despite these challenges, Brazil's auto sector bounced back partly due to policy signals aimed at revitalizing the industry. Approximately 2.5 million cars and vans were sold in 2024 (a 14% increase from 2023 and more than half a million over the 2022 number), along with 149,774 trucks and buses. Electric and hybrid vehicle sales, starting from a much smaller sales figure, increased by 88.7% from 2023 to 2024, showing the potential of the market for electrified vehicles.<sup>40</sup>

Figure 5. Market growth opportunity of hybrid “flex” (battery plus ethanol) is greater than pure battery electric vehicles



Source: Robbie Andrew, CICERO; Data: ANFAVEA<sup>41</sup>

So far, the Brazilian policy mix, mostly represented by the Mover program but complemented by financing from the BNDES—as exemplified by the Volkswagen case mentioned above—has delivered tangible results. Multinationals have announced over \$20 billion in new investments in the country through to 2033 (Table 3), and new ventures like BYD’s in Camaçari seem to be just the beginning. If battery production advances in tandem, Brazil could be poised to become a green value-added hub.<sup>42</sup>

However, challenges remain, extend beyond the localization of battery components, and echo those Brazil has faced with its traditional automotive sector for decades. Almost all companies operating in Brazil—except for smaller firms like Lecar and Eletra—are large multinationals, many of which will conduct most of their R&D abroad, if not motivated to do so nationally. In this context, the Mover program plays a crucial role by offering tax incentives to encourage in-country R&D, which could also benefit from Brazil’s unique expertise in ethanol and flex-fuel motors.<sup>43</sup>

As such, the recent increase in tariffs, as much as 35% for EV imports that exceed the annual quota, aims to accelerate the installation of local production capacity. This increase was supported by more traditional car manufacturers represented by ANFAVEA and opposed by the EV-focused association ABVE.<sup>44</sup>

Table 3. EV and hybrid flex(battery-ethanol) production plants of both domestic and foreign-owned subsidiaries of auto firms 2022-2024

Firm	Plant type	Investment	Location	Capacity (vehicles p.a.)
Toyota	Hybrid	\$2.2 bn	São Paulo	100,000
Hyundai	Hybrid	\$3.8 bn	São Paulo	210,000
GM	Hybrid	\$1.4 bn	São Paulo	330,000
Volkswagen	Hybrid	\$1.8 bn	São Paulo	140,000
Stellantis	Hybrid	\$5 bn	São Paulo	1.1m engines
Renault	Hybrid	\$0.85 bn	Parana	178,000
CAOA Chery	Hybrid	0.75 bn	Goiás	72,000
BYD	Hybrid	\$0.91bn	Bahia	150,000
Great Wall Motors	Hybrid	\$1.66bn	São Paulo	50,000

Source: NZIPL analysis of FDI Intelligence data

### Sustainable aviation fuel (SAF)

Sustainable aviation fuel (SAF) will play a key role in decarbonizing global air travel. SAF markets are rapidly growing to meet demand driven by a European and Chinese mandate and various subnational regulations such as the California and British Columbia low-carbon fuel standards (LCFS).<sup>45</sup>

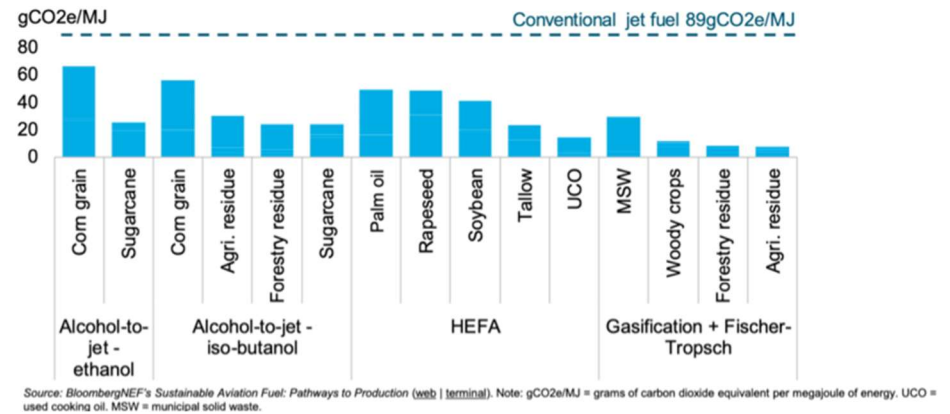
Brazil has the potential to be a world leader in SAF.<sup>46</sup> Brazil's bioeconomy has boomed on the back of major growth in agribusiness. It has the feedstock, the oil and gas expertise, and the foothold in biofuels to scale rapidly into SAF value chains.

Brazil has two major forms of feedstock, which are used into different SAF pathways.<sup>47</sup> First, Brazil's agriculture sector produces tallow (from beef processing), soybean oil, and palm oil all of which can go into the hydroprocessed ester and fatty acids (HEFA) pathway. Four projects in Brazil currently seek to achieve this: Brasil BioFuels, Essential Energy USA, and two Petrobrás projects are in development.<sup>48</sup>

Second, Brazil's sugarcane ethanol production could be diverted into an alcohol-to-jet (AtJ) pathway. Brazil produced 35.4 billion liters of ethanol in 2023, mainly from sugarcane, and currently blends most of it into gasoline. Shell and Raizen have announced that they are exploring an AtJ project in Brazil.<sup>49</sup> Brazilian AtJ would have a critical advantage: it has very low carbon intensity (Figure 6). Its carbon intensity is one-third of the emissions of corn ethanol, and less than half the emissions of canola, palm, or soybean-based SAF. The way LCFS markets

are developing, low-carbon SAF will fetch higher prices because those markets pay per unit relative to a fossil benchmark. This puts Brazilian AtJ in a strong position.

Figure 6. Carbon intensity of SAF by feedstock and technology.



Source: BloombergNEF.<sup>50</sup>

Alcohol-to-Jet is not yet fully commercial, so Brazil has an opportunity to get into the technology value chain at the outset. There will also be opportunities for international collaboration and for partner countries to provide technology transfer to Brazil in this area. The risk of Brazil not moving into SAF technological development is that the country exports its abundant sugar ethanol to SAF plants abroad and imports the value-added SAF instead.

If ethanol producing countries such as the US and Brazil work together on SAF they can address a common problem: ethanol is susceptible to demand destruction as electric vehicles reduce gasoline use. A strong, growing SAF market can absorb ethanol from both countries while keeping ethanol prices high. This will reduce resistance to the transition from agricultural producers. Brazil's Raizen is already sending ethanol to a US SAF plant owned by LanzaJet in Georgia.

Brazil is expected to design a SAF mandate that would go into effect from January 2027 but policy details are still under consideration.<sup>51</sup> For now, the Fuel of the Future law requires airlines to cut their carbon emissions (starting at 1% in 2027 and peaking at 10% in 2037). Companies have started scrambling to produce SAF, with pledged investments to the order of just under \$3 billion dollars until 2027. Out of the major players, Acelen has pledged to produce 1 billion liters a year of SAF from the macaúba palm, with technology licensed from Honeywell, and has received a BNDES loan of approximately \$43 million.<sup>52</sup>

Brazil is already becoming a magnet for SAF investment by oil companies, international investors, and sovereign wealth funds<sup>53</sup>. Shell and Abu Dhabi's Mubadala investment company are considering SAF AtJ plants, with Mubadala

already owning Acelen. Another potential major player is Petrobras, which is developing SAF out of soy oil and beef tallow.<sup>54</sup> FINEP and BNDES have also released a public call for projects offering \$1 billion for SAF projects; in total, it received \$20 billion worth of proposals for SAF development.<sup>55</sup>

## Wind turbines

Brazil is the world's number three wind market, with 5 GW of deployment in 2023.<sup>56</sup> Because turbines are large, manufacturing for final assembly and critical components tends to be co-located with deployment. Nacelle and hub production in a given jurisdiction often scales up and down with the deployment market.

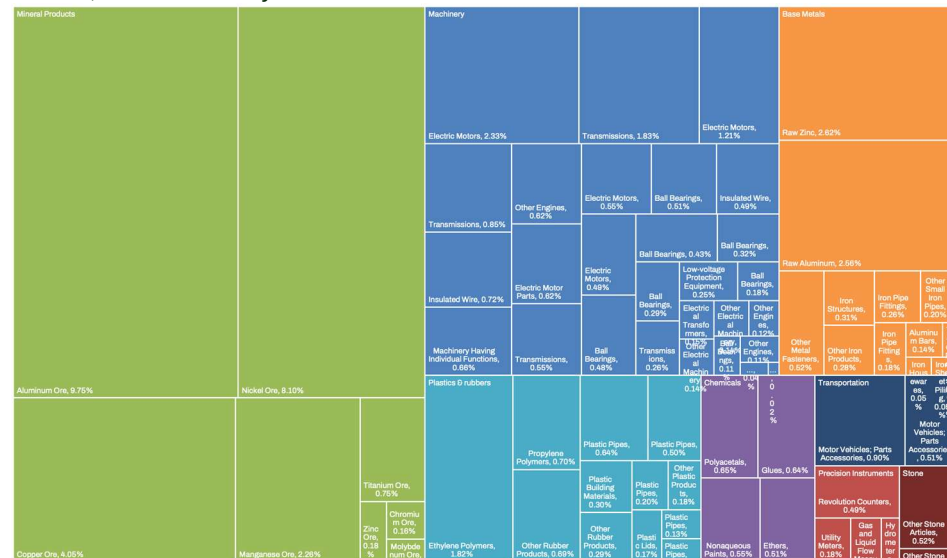
Vestas (2.1GW), GE (1.2GW), Nordex (650MW), Siemens Gamesa (580MW), Goldwind (180MW), and WEG (172MW) all manufacture turbines inside Brazil.<sup>57</sup> But from an industrial policy perspective, the key question is what percentage of the value-add for these turbines happens in Brazil. In global supply chains, complex components are often imported, leaving the least complex final stages for local assembly. This means that turbine manufacturing may not generate broader economic benefits without targeted policy interventions.

Brazil, led by BNDES, has been aiming to build the local supply chain for wind turbine components since 2002. For a brief period, Brazil had a renewable feed-in-tariff that required 60% local content (calculated by weight).<sup>58</sup> This scheme did not have much success and was replaced with an auction system without local content requirements. In 2012, BNDES advanced a new local content roadmap covering towers, blades, hubs, and nacelles. In this scheme, BNDES would only offer its concessional loans, as low as 2.5%, to developers that met local content targets. The policy has been a mixed success.<sup>59</sup>

On one hand, the local content targets for towers and blades have been lowered from 60% in 2016 to 30%.<sup>60</sup> Hubs and nacelles are not subject to a value-added target but must be assembled locally. The reduction of the requirements reflects the lack of local sourcing options. On the other hand, the requirements have helped build up a local industry for blades, towers, bearings, and castings.<sup>61</sup>



Figure 7. Brazil's exports in the wind production and supply chain: strengths in minerals, metals, and machinery.



Source: NZIPL analysis of UN Comtrade data.

The policy captured by the BNDES shows some adaptation capacity by Brazilian industrial policy institutions. Given the infant nature of the supply industry—especially in the beginning of the policy—accreditation mechanisms were adjusted to be more flexible, depending on the technological sophistication, with technically more challenging components being allowed lower national content. This has incentivized some learn-by-doing of national companies, creating important success stories<sup>62</sup>, like WEG, a Brazilian industrial powerhouse for electric motors who moved into the production of parts and components for wind and other clean energy sectors across Brazil and Latin America.<sup>63</sup> As a result, Brazil's only major imported component for wind turbines nowadays are gearboxes, with local content revolving around 85-95% depending on the chosen hardware for a given project.<sup>64</sup>

This has been an essential step, which attracted international players and created linkages to local producers. However, a deeper look at the Brazilian industrial base reveals that the strategy to create local content has not necessarily created a competitive global industry. Brazilian exports of products in the wind supply and process chains demonstrate moderate strength, but the sector is particularly hampered by infrastructural bottlenecks that bar the country from selling large wind turbine parts even to neighboring countries.<sup>65</sup>

These infrastructural bottlenecks are not natural facts. Before Brazil was able to export record volumes of iron and soy to China, it had to build logistical supply chains to get the products to expanded, modern ports.<sup>66</sup> This work began at an

early stage of the industrial policy roadmap so that the export infrastructure would be ready when the plan came to fruition. A similar level of organization and commitment to infrastructural development is needed to generate exports for a sector with large, complex components such as wind.<sup>67</sup>

At present, Brazil's wind energy sector is undergoing significant changes. As a first response to advancements in national production and to falling demand, import tariffs for wind turbines have been raised. Previously, turbines with capacities above 3,300 kVA were exempt from import taxes due to the absence of equivalent domestic products. Now, this threshold has increased to 7,500 kVA, with the exemption valid only until 2025. After that, all foreign purchases will incur an 11.2% import tax barring the absence of equivalent domestic production. In parallel, WEG has secured a \$12 million loan from BNDES to develop an onshore wind turbine with a 7.0 MW capacity and a 172-meter rotor blade diameter, potentially capable of meeting the new threshold.<sup>68</sup>

As such, the wind sector continues to grapple with demand challenges, as projects often favor cheaper imported solar panels that are incentivized by government policy. To further address these issues, the MDIC convened a working group that produced a report for the Chief of Staff (Casa Civil). The group identified the legal framework for offshore wind as a key opportunity for Brazil's electricity generation.<sup>69</sup>

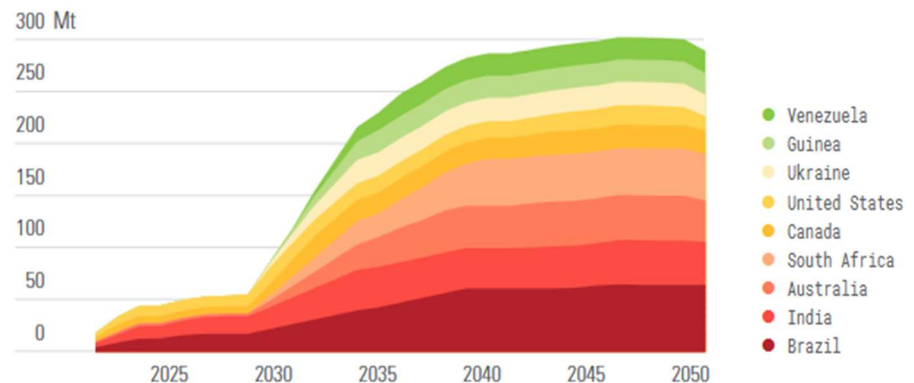
The bill's passage in the Senate was a milestone, though it included controversial and unrelated provisions benefiting thermoelectric plants that could increase national emissions by 25%.<sup>70</sup> While these provisions were vetoed, Congress retains the power to override the decision.<sup>71</sup> The framework stands as a landmark achievement, with the potential to supply up to 19% of Brazil's current electricity demand under the most ambitious offshore wind scenario, while also serving as a major catalyst for the growth of the country's wind manufacturing industry.<sup>72</sup> When accounting for offshore wind, the sector's potential grows exponentially. As such, policy design needs to reflect the specific challenges and opportunities of each sector, using targeted data to guide decisions. In wind energy, Brazil must develop a coordinated strategy with clear targets and strong government support to build a competitive ecosystem. This is particularly crucial for mature sectors that still lack globally competitive firms and a well-integrated industrial base to support long-term growth.<sup>73</sup>

## Low-Carbon Steel

Brazil's existing steel industry, clean power, and mining strengths provide a strong base to produce low-carbon steel. There is a big import substitution and value-added opportunity here as currently Brazilian ore is exported and then reimported as steel, allowing other countries to capture the intermediate value-added.

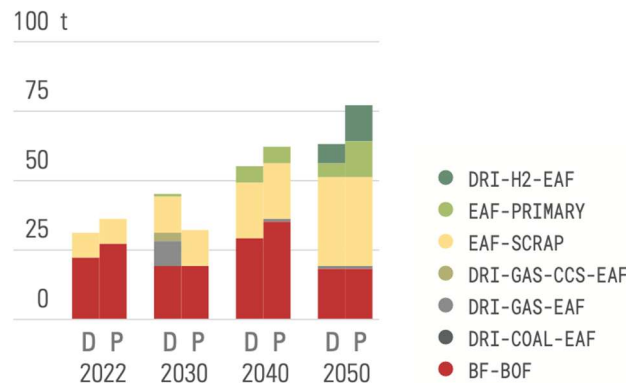
A recent analysis by the Net Zero Industry Project highlights Brazil's opportunity as a leading, low-cost destination of low-carbon steel.<sup>74</sup> They model a scenario in which countries in the global north create a broad carbon club: a shared market backed with a carbon border adjustment mechanism. In this scenario, Brazil emerges as a key location for the low-carbon production of iron and direct reduced iron, a critical input for the leading DRI-EAF primary steelmaking pathway (Figure 8).

Figure 8. Global green iron production in the Net Zero Industry Project's broad climate club scenario.



Source: Bataille et al 2024.<sup>75</sup>

Figure 9. Brazil's green steel potential in the Net Zero Industry Project's broad climate club scenario.



Source: Bataille et al 2024. D is domestic demand; P is production.<sup>76</sup>

It also emerges as a major exporter of low-carbon steel in this model (Figure 9). Brazil's low cost of capital and cheap electricity position it as a potentially leading producer of green steel via both leading net-zero pathways: electric arc furnace and direct reduced iron with hydrogen.

Steel is also a critical sector for Brazilian hydrogen. Our analysis, rather than focusing on hydrogen production, focuses on the demand-side. A low-carbon

steel sector provides a market for hydrogen. At present, the size of the global trade in hydrogen is highly uncertain, as is Brazil's competitive position within that market. Thus, Brazil should focus on scaling and cost discovery with domestic demand. Indexing hydrogen to a domestic low-carbon steel sector is a major opportunity here. This potential must be nuanced, however, given this pathway's uncertain commercial viability at the moment.<sup>77</sup>

A critical piece of the global low-carbon steel market is the creation of a climate club for steel. In this regard, the EU's carbon border adjustment mechanism (CBAM) is the leading proposal. While some countries in the global south have resisted the CBAM, it can be used as an opportunity for countries that strategically position themselves.<sup>78</sup> There is an international dimension to certifications and a taxonomy of low-carbon steel, which is crucial to create demand for a potentially more expensive product.<sup>79</sup>

In this vein, Brazil should consider implementing a domestic CBAM aligned with its Sustainable Taxonomy. This policy would protect Brazilian steel manufacturers while maintaining some competitive pressure and could be tailored to maximize Brazil's advantage as a producer of clean energy.

In this context, Brazil has a narrowing window of opportunity to address some key problems in its domestic steel industry: 74% of Brazilian steel production relies on the carbon-intensive BF-BOF process, though there is a lower cost opportunity here, as some producers have adopted biochar as an initial decarbonization solution<sup>80</sup>. Vallourec exemplifies this approach, having secured a \$9 million loan from BNDES's climate fund to expand its biochar operations.<sup>81</sup>

Brazil also has no operating DRI plants, despite the upstream national expertise on the production of pellets and Hot Briquetted Iron by Vale, who is now partnering with Swedish H2 Green Steel to produce HBI with low-carbon hydrogen. Vale is setting up mega-hubs equipped with DRI furnaces in Saudi Arabia, UAE, and Oman.<sup>82</sup>

Despite the potential, pursuing the DRI-H2-EAF route would require immense investments. Brazil would need to build expertise in DRI and establish industrial capacity for electrolyzers. As the sector is still in its infancy, with localization initiatives just beginning, this will likely be a longer-term pathway.<sup>83</sup>

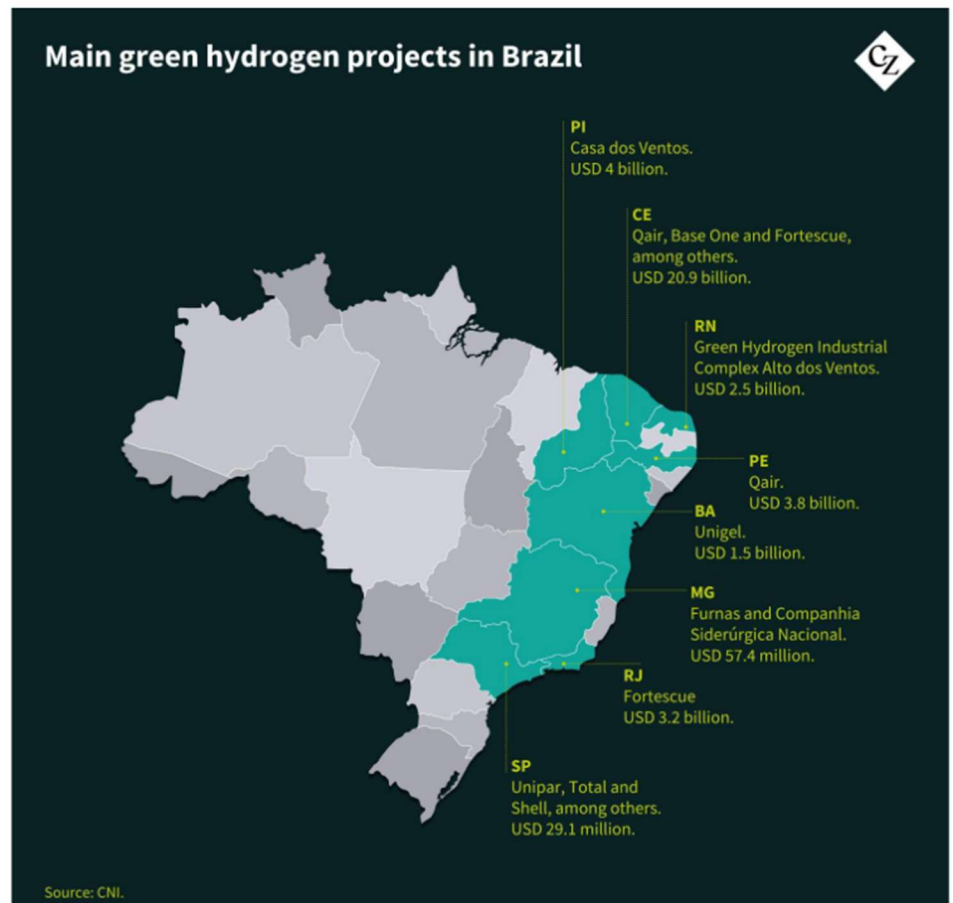
Conversely, Brazil can immediately accelerate its decarbonization efforts by encouraging major industry players—like Gerdau and ArcelorMittal—to increase their steel production via the Scrap-EAF methodology. This approach uses known and available technology and would be clean given the Brazilian energy production, but it requires a steady and sufficient supply of scrap metal, and hence a comprehensive scrap policy to promote domestic recycling and the decommissioning of offshore platforms.<sup>84</sup>

Despite recognizing the steel sector's strategic importance and even treating it as a possible 'flagship project', Brazilian policymakers have not yet developed targeted policies for low-carbon steel. Their focus has been on defending domestic producers by raising tariffs to 25% on 11 steel product categories to guard against Chinese competition.<sup>85</sup> While this protection may help stimulate investment in a sector struggling with idle capacity, more targeted interventions are within reach and are necessary to decarbonize the industry and capitalize on the country's potential for low-carbon steel production.<sup>86</sup>

### Green Fertilizer

Green fertilizer is another opportunity for hydrogen. It also presents an opportunity to reduce imports. Brazil is the number one importer of fertilizer in the world. A critical feedstock for fertilizer is hydrogen, which is the base for ammonia ( $\text{NH}_3$ ).<sup>87</sup>

Figure 10. Green hydrogen projects with green steel and green fertilizer potential.



Source: CNI.<sup>88</sup>

Currently, fertilizers are predominantly made with gray hydrogen produced by steam reforming natural gas ( $\text{CH}_4$ ), which releases enormous amounts of carbon.

Making fertilizer with green hydrogen drastically reduces the emissions intensity of fertilizer.

Atlas Agro recently announced a \$1.15 billion project to develop green fertilizer in Uberaba.<sup>89</sup> The project will utilize 300 MW of clean energy to produce green hydrogen, ammonia, and nitrogen fertilizers.<sup>90</sup> This is a great project: it will reduce imports and create value-added. Yet, it is important to ask whether there is a broader industrial strategy to keep it competitive and integrate it into an ecosystem that maximizes Brazil's long-term advantages? Green fertilizer is a clear target for technology transfer, in order to build domestic firms along the value chain. Investments in chemical knowledge and the hydrogen value chain around fertilizer will pay dividends over decades. Other than AtlasAgro, another 11 projects were chosen by the Ministry of Mines and Energy as potential low-carbon hydrogen hubs and as possible recipients of Climate Investment Funds for Industrial Decarbonization (CIF-ID), showing the government's interest in low-carbon hydrogen.<sup>91</sup>

Given its importance to the Brazilian economy, the sector was included in Mission 1 of the NIB. Despite some incipient ideas discussed by the National Fertilizer Council to create sustainable fertilizers through the transformation of sewage treatment residuals, the more traditional fertilizer decarbonization path has progressed slowly. The legal framework for green hydrogen only passed in August 2024, which put most projects to capitalize on Brazil's competitive advantages in this area on hold or in a very incipient phase.<sup>92</sup>

Furthermore, Brazil's import-reliance is hard to break. New tariffs were considered in October 2024 but were eventually scrapped given the possible cost pressure of more expensive imported fertilizers for agricultural producers.<sup>93</sup> This runs counter to the National Fertilizer Plan, which states that the country should increase the market share for domestically produced fertilizers from the current 15% to 55% by 2050.<sup>94</sup> At present, however, the country produced only one for every seven million tons of urea it imported and until 2022, large national producers were actually shutting down plants.<sup>95</sup>

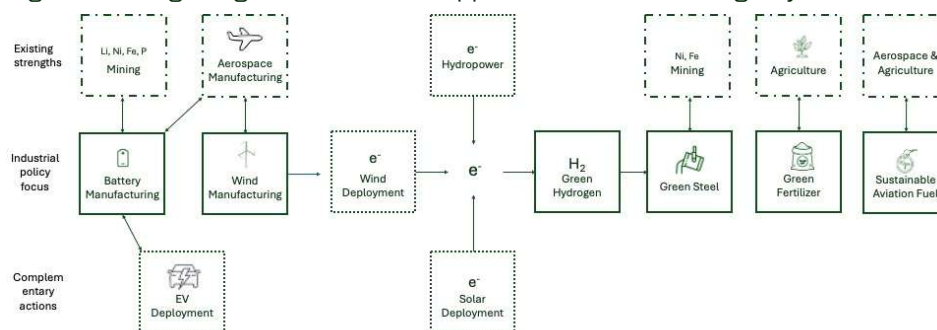
As such, existing initiatives have mostly focused on localization, but this could kickstart decarbonization efforts. Other than Atlas Agro, another clear example is the reactivation of the Araucária fertilizer plant in Paraná. Petrobrás invested over \$145 million in the project,<sup>96</sup> simultaneously partnering with Embrapa, Brazil's national agricultural research agency,<sup>97</sup> and Norwegian firm Yara to develop decarbonization initiatives.<sup>98</sup> Reviving domestic production capacity could be a first step in laying the groundwork for a more sustainable and decarbonized fertilizer industry in Brazil, but clear incentives towards this goal are needed if localization is to be leveraged.

## Integrating sectoral strategies

To ensure that sectoral initiatives add up to more than the sum of their parts, there are opportunities to integrate these sectoral opportunities into systems. In driving development and decarbonization, structural transformation of systems is critical. Part of what the government must do is not just provide capital and project support, but create broader conditions for transformation with forward-looking investments in infrastructure, human capital, and cheap energy.

The first step in identifying these investments is to map value chains and think about the resources and potentials that will be needed to capture key nodes and keep them globally competitive. Figure 11 presents a start for this mapping.

Figure 11. Integrating Brazil's sectoral opportunities into a strategic system



## Strategic investments in education and innovation

Even if all industrial policy initiatives are coherent, conditional, and well monitored, technological clusters need specialized and educated workers. This will demand a dedicated plan to train the Brazilian workforce with aims to tap into the country's massive potential and position it as a leader in the geopolitics of the energy transition.<sup>99</sup>

The Industrial Labor Map calculated by the Brazilian National Industry Confederation (CNI) estimates that Brazil will need to train 14 million people to attend the demand for formal workers.<sup>100</sup> That can be a challenge, since Brazil has one of the lowest enrollments in Vocational Education and Training (VET) out of all OECD member and partner countries.<sup>101</sup>

The 2023 Legal framework for Technical Education could help address this gap. The framework establishes a monitoring system for VET and allows technical education students to use their credits toward a college degree if they choose.<sup>102</sup> While the details of implementation are still under discussion by the Ministry of Education, this framework will be part of the National Policy for Technological and Professional Education (PNEPT).<sup>103</sup>



Although improving VET can be seen as a ‘horizontal’ human capital policy, Brazil will need to target its investments in workforce training towards the sectors where it has the biggest potential. As such, an explicitly ‘vertical’ policy for VET is needed and can be piloted in decarbonization niches, thus complementing the country’s industrial policy push.

Brazil’s existing VET system offers a mixed foundation for such efforts. SENAI, one of the most established providers of VET for manufacturing, plays a critical role in workforce training. Together with SENAC (focused on commerce and services), these institutions are funded through payroll taxes and form part of the ‘Sistema S.’ However, as business-led organizations, they primarily cater to the needs of the current industrial structure and are more responsive to market incentives than government policies. If decarbonization becomes central to Brazil’s industrial future, SENAI is likely to adapt, but its current structure limits its proactive role in driving change.

As such, investing on the *Institutos Federais* (IFs) could be Brazil’s best bet in pursuing a targeted VET policy. In March 2024, Lula announced 100 new IFs with 140,000 vacancies, to be built using funds from the new PAC. These new units are mandated to provide at least 80% of their vacancies to VET—up from 50% for previous IFs. In the same event, he said that the goal was to climb from the current 682 IFs to 1,000.<sup>104</sup>

Since 2015, some of these institutes have been selected to host innovation units in partnership with Embrapii, highlighting their potential as critical nodes within technological hubs. These Embrapii Innovation Poles already serve as valuable R&D opportunities, with several of them linked to *Institutos Federais*.<sup>105</sup>

A crucial next step would be to align these partnerships with Brazil’s decarbonization agenda by incentivizing the development of targeted curricula and workforce training programs. For instance, pilot programs could leverage recent investments in EV and wind energy industries near Camaçari, adapting the existing Electrical Technician VET program at the local Instituto Federal to meet the demands of these rising sectors. Once tested and refined, such initiatives could be expanded to other regions and industries, creating a scalable model for workforce development aligned with Brazil’s green industrial strategy.

### Focusing Science, Technology, and Innovation policy on priority productive chains

Brazil has a Regulatory Framework for Science, Technology and Innovation (ST&I) and several existing public policy instruments within BNDES and FINEP—subsidies, subventions grants, subsidized credit, equity, tax incentives—and programs in place to stimulate human capital for its strategically chosen industries.<sup>106</sup> NIB’s Mais Inovação Brasil aims to invest \$11 billion in companies’



innovation projects until 2026, with CNDI prioritizing missions and structural axes defined by the Ministry of Science, Technology and Innovation (MCTI).<sup>107</sup>

Historically, for such strategic industries, these instruments and programs have led to coordinated Government-industry-university cooperation for development and acquisition of technologies. Hence, there has been a sustained increase in patent production and domestic knowledge creation in production chains for Brazil's 'islands of excellence': Petrobras's oil exploration, EMBRAPA's biofuels and agribusiness, and Embraer's aviation production chain.

The question now for Nova Industria Brasil is whether such integration—of science with innovation, and of companies with universities—can be replicated in a focused way on the new priority production chains.

## Historical Case Study

Brazil has had successful cases of co-producing relationships between investments on industrial policies and on education and innovation policies focused on creating the human capital required by strategic industries. The main examples of strategic knowledge creation and innovation have been the two previously state-owned enterprises Embraer and Petrobras and their respective research institutions ITA and Cenpes.

**Embraer and ITA:** ITA is a public superior education institution owned by the Brazilian Air Force focused on aerospace engineering. The origins of ITA are intertwined with the creation of a Brazilian Air Force in the 1940s and with the development of a national aeronautic industry. ITA was strategically created to develop human capital to incubate a future domestic aeronautic industry, amidst a time in which the Brazilian economy heavily relied on agricultural exports and industrial imports. In partnership with the Massachusetts Institute of Technology, brigadier Casimiro Montenegro Filho, and his team, all MIT alumni, founded ITA in 1948, aiming at developing the basis for Brazil's aerospace industry through knowledge production. ITA was under a newly created government body called the Aeronautic Technological Center (CTA), focused on aerospace research. In 1968, CTA's first airplane, the Bandeirante aircraft, was built by ITA engineers. At the time, Brazil was under the Military Regime that lasted from 1964 to 1985. After the Bandeirante aircraft was first built, the question of a mass production complex to achieve economies of scale was paramount. So, in 1969, Embraer was founded as an aerospace corporation focused on manufacturing aircraft in Sao Jose dos Campos, and BNDES supplied the credit for Embraer's first major sale contract of jets to American Airlines. The government also acted as a buyer to support Embraer and knowledge production, using public procurement to buy 80 Bandeirantes, 112 military aircraft, and 50 agricultural aircraft. Currently, ITA and Embraer cooperate on post-graduate courses focused on engineering research, one creating the conditions of possibility for the existence and investment of one another.

**Petrobras and Cenpes:** A second example of a co-productive investment in industrial policy and human capital policy is the creation of the Centre for Research, Development, and Innovation Leopoldo Americo Miguez de Mello (Cenpes) and Petrobras. Petrobras, once fully state-owned, is Brazil's largest oil company, and was created in 1953 by President Getúlio Vargas. At the time, Brazil's petroleum production was focused primarily on the extraction of raw material and exportation, especially to the US. Petrobras was an effort to create infrastructural conditions of possibility for national petroleum extraction and processing, and to develop a production geared towards the national market. Therefore, the need for skilled labor and human capital led to the creation of Cenpes, in 1963, an applied research center focused on the research and development of petroleum processing, gas and energy technology, transportation and commercialization of petroleum located in Rio de Janeiro, close to Petrobras headquarters. Cenpes works in partnership with Brazilian universities and national and international research institutes.

The technologies that Cenpes pursues as its focus changes based on the strategic requirements of Petrobras and Brazil's relative position in the global oil market. Cenpes' focus was downstream and midstream in its early phase, namely petroleum refining in the 1960s and 1970s. But when pre-salt formations were discovered by Petrobras, the strategic focus of Cenpes was changed to upstream research and development of deep-water petroleum extraction and offshore technologies from the mid-2000s onwards. In order to develop this domestic know-how of logistics, geology, and environmental protection, Cenpes and Petrobras developed technical exchange programs with the leading US and Norwegian companies that develop offshore technologies.

## Conclusion

Brazil has world-leading potential in the new geopolitics. As the global energy order shifts, the countries that matter most will be those that are able to leverage large natural resource bases into manufacturing value-added and high-employment service sectors. Brazil can build on its existing strengths to create world-leading industries in the seven sectors we analysed in this report: critical minerals mining, battery and EV manufacturing, wind manufacturing, sustainable aviation fuels, low-carbon steel, and fertilizers.

To take advantage of these opportunities, Brazilian industrial policy must have three critical features:

1. Focus: clear targets in a limited number of sectors, with a clear sense of where Brazil's subsectoral opportunities are. Nova Industria was, initially, too broad and unfocused. The Ecological Transformation plan aims to get more targeted and sectoral. However, robust, quantitative targets are needed to help make hard decisions with scarce resources.
2. A strong coordination process: successful industrial policy is built on good information flows between government, industry, and experts, and between levels of government.
3. Structural investments in education and innovation: Brazil needs to build the innovation base to compete with other leading economies in the new energy geopolitics. But without highly focused efforts to build knowledge in specific areas, Brazil's industrial policy will not realize its potential.

Brazil has fiscal constraints like other developing countries in the energy transition. Even without a large budgetary allocation for industrial policy, it can conduct strategic investment through BNDES. However, it must ensure that its industrial policy adds up to more than a series of disjointed projects.

Rodrik and Stiglitz have recently argued that the well-known path to development via manufacturing and exports has become more difficult.<sup>108</sup> Manufacturing no longer absorbs labor at high rates and Chinese dominance of manufacturing has created a highly competitive landscape. This leads them to highlight the crucial role of services sectors in development. However, they correctly note that “increasing productivity in labor-absorbing services is likely to prove more difficult than in manufacturing” and that “the expansion of non-tradable services—those that are most likely to absorb employment—is ultimately limited by the size of the home market.”<sup>109</sup> This suggests that there are important constraints on the potential of services-led growth.

There is, however, another route that has been laid out by Carlota Perez. Perez argues that countries can build complex, dynamic industries around their natural resource base.<sup>110</sup> The key is to avoid primarization and commodity dependence. She argues this can be achieved with industrial policies that focus on establishing technologically sophisticated production networks that diversify the economy beyond commodities. Natural resources are a “springboard for industrialization and economic development” beyond resource dependence, as long as linkages are created and maintained.<sup>111</sup> Creating linkages from natural resources poses economic and political challenges, but it can be achieved through targeted policy decisions.<sup>112</sup>

This is a clear path for Brazilian growth overall. Brazil’s strengths in agriculture and critical minerals provide a base for productive investment in manufacturing and processing industries in linked sectors. Pursuing these linkages with well-designed industrial policy provides a way to leverage natural resources and manufacturing into a growing services sector, and therefore into broad-based structural transformation.

## Methodological Annex

### Radar Methodology for Figure 1 – Brazil's natural resource potential for the new energy geopolitics

**Solar potential** is taken from the World Bank SolarGIS dataset, using the Level 1 indicator for potential utility-scale photovoltaic (PV) generation.<sup>113</sup> This Level 1 indicator excludes areas which are assessed as not being practical for utility-scale PV development, due to physical unfeasibility and technical land-use constraints.

**Wind potential** is measured based on data provided by Tonelli and others, who estimate the maximum capacity in TWh/yr a country can produce from onshore wind or PV solar resources if all eligible available land is used for solar or wind.<sup>114</sup> The analysis assumed the use of 100% of all land considered suitable for wind. 10% of forested land was deemed eligible for wind power generation, and 70% of agricultural land was deemed suitable. No urban land was considered suitable for wind. This variable does not consider the offshore wind generation potential, which is analysed in the report based on a report by the World Bank.<sup>115</sup>

**Green Electrolysis Potential** was estimated using a mean of total production potential based on solar or wind resources, taking the availability of power or water as a limiting factor. Estimates of solar and wind potential were used to determine potential hydrogen production from each renewable resources, subtracting for national power demand.<sup>116</sup> An electrolyser efficiency of 50 kWh per kilogram of hydrogen produced was assumed. Water requirements were assumed to be 32 kg per kg hydrogen for PV solar-based production and 22 kg per kg hydrogen for wind-based production.<sup>117</sup> Water availability was calculated as total available water minus water consumption for countries without readily available sea access.<sup>118</sup> For countries with readily available sea access, water availability was not presumed to be a limiting factor due to advances in desalinization and its potential for pairing with electrolysis. Readily available sea access was determined based on total national coastline. For both wind and solar production options, potential hydrogen production was based on the limiting factor, either electricity or water. The mean of the two resulting hydrogen production estimates from solar and wind production respectively was the final estimate used. Note that negative withdrawals of water beyond national availability resulted in a negative hydrogen score for some countries, in which case a value of zero was assigned.

**Critical minerals potential** is an indicator calculated by the NZIPL based on national reserves for seven minerals (cobalt, copper, lithium, nickel, manganese, phosphate, and bauxite) from USGS data.<sup>119</sup> For each mineral, national reserves were calculated as a proportion of the largest national reserve globally for each mineral. The mean of these seven proportional values was then calculated, and a logarithmic scale was used.

**National biocapacity** is based on the dataset from Global Footprint Initiative at York University.<sup>120</sup> This is based on an estimate of biological productivity, measured in a standardized hectare value. For the current analysis, a sum of biocapacity from cropland, forest land, and grazing land was calculated for the year 2022.

**Oil and gas** reserves were taken from the US Energy Information Administration. A logarithmic scale is used.<sup>121</sup>

## **Radar Methodology for Figure 2 – Brazil's advanced manufacturing potential for the new energy geopolitics**

**Export Complexity** was taken from the Observatory of Economic Complexity's ranking of countries for the year 2021.<sup>122</sup>

**Green Manufacturing Exports** are measured by a score of Green Energy Manufacturing Exports and was arrived at by taking the dollar valuation from UN Comtrade data for all national exports from 2016-2022 for HS codes which aligned with a clean energy technology as defined by the IRENA patent database. The sum of dollar values was then logged.

**Renewables Patents** was taken from an IRENA database and patents by national origin were summed for the years 2000-2021. Patents include those for; Batteries, Biofuels, CCUS, Crosscutting, Electromobility-Charging Stations, Electromobility - Energy Storage, Electromobility - Information/Communication Technologies, Electromobility - Machine related technology, Energy Efficiency, Energy Storage - General, Fuel Cells, Fuel from waste, Geothermal Energy, Green hydrogen (water electrolysis), Heat pumps, Hydrogen (storage and distribution and applications), Hydropower, Mechanical energy storage (e.g. flywheels or pressurized fluids) Ocean Energy, Others, PV, PV - Thermal Hybrid, Smart Grids, Solar Thermal, Thermal energy storage, Ultracapacitors, supercapacitors, double-layer capacitors, Wind Energy.

**R&D** is calculated with the National R&D as a % of GDP and was taken from the World Bank, an average of 2016-2022 was used.

**Education** is calculated with the Gross Enrollment in Tertiary Education and was taken from the World Bank and measures the total enrollment in tertiary education in a nation relative to the corresponding age group most likely to be enrolled. An average was taken for the years 2016-2022.

**Household and business electricity prices** were taken from Global Petrol Prices, for March 2023 in the case of household prices, and December 2023 in the case of business prices.<sup>123</sup>

**Net Zero Grids** are calculated with the carbon intensity of national grids. This was taken from Our World in Data and measures the percentage of renewable and nuclear energy on a nations grid for the year 2021.

## Notes

<sup>1</sup> <https://www.irena.org/publications/2019/Jan/A-New-World-The-Geopolitics-of-the-Energy-Transformation>

<sup>2</sup> See annex for NZIPL's ranking methodology. We have applied the same methodology to all countries, and will be releasing the global ranking in a future research note.

<sup>3</sup> See the methodological annex for details. Offshore wind could not be added to the radar at this time due to lack of reliable potential data. Offshore wind is, however, included in our analysis of the sector below.

<sup>4</sup> Arbache, Jorge and Luíz Esteves (2023). Resiliência com eficiência: Como o powershoring pode colaborar para a descarbonização e o desenvolvimento econômico da América Latina e Caribe. Caracas: Banco de Desenvolvimento da América Latina e Caribe.

<https://scioteca.caf.com/handle/123456789/2078>; Arbache, Jorge (2022). "Powershoring". CAF, Banco de Desenvolvimento da América Latina. Video:

<https://www.caf.com/pt/conhecimento/visoes/2022/11/powershoring/>; Jiajun Xu, and Régis Marodon. 2023. Public Development Banks and Development Financing Institutions Database. Peking University Open Research Data Platform. <https://doi.org/10.18170/DVN/VLG6SN>.

<sup>5</sup> <https://www.wsj.com/articles/a-factory-exodus-is-hollowing-out-brazils-industrial-heartland-83505647>

<sup>6</sup> Morceiro, Paulo and Joaquim Guilhoto. 2023. Sectoral deindustrialization and long-run stagnation of Brazilian manufacturing. Brazilian Journal of Political Economy Vol. 43, No. 2.

<https://www.scielo.br/j/rep/a/jyQCmYg8BPPFWbFRjG7tGSq/>; Nassif, André and Paulo Morceiro. 2021. Industrial policy for prematurely deindustrialized economies after the Covid-19 pandemic crisis: Integrating economic, social and environmental goals for Brazil. Paper Presented at the 25<sup>th</sup> Conference of the Forum for Macroeconomics and Macroeconomic Policies (FMM), Berlin.

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<sup>7</sup> Jenkins, Rhys. 2015. Is Chinese Competition Causing Deindustrialization in Brazil? Latin American Perspectives Vol. 42, No. 6, pp. 42-63. <https://www.jstor.org/stable/24574023>

<sup>8</sup> <https://comexstat.mdic.gov.br/en/geral>

<sup>9</sup> Jenkins 2015, 43.

<sup>10</sup> Thus, some have argued that China is responsible for the "primarization" of Brazil's economy by reducing it to an exporter of primary goods (Jenkins 2015, 55). Deindustrialization and primarization can have negative economic consequences from creating currency volatility (by linking it to commodity markets) to increasing inequality (by shifting employment out of high wage jobs and empowering large commodity firms). Finally, since manufacturing itself is important in the overall process of development (due to unconditional labor productivity, labor absorption, and export potential) it can hamper the process of structural transformation (See Rodrik 2016; Chang, Ha Joon, Antonio Andreoni, and Ming Leong Kuan. 2013. International industrial policy experiences and the lessons for the UK. Future of Manufacturing Project: Evidence Paper 4).

- <sup>11</sup> [https://unfccc.int/sites/default/files/2024-11/Brazil\\_Second%20Nationally%20Determined%20Contribution%20%28NDC%29\\_November2024.pdf](https://unfccc.int/sites/default/files/2024-11/Brazil_Second%20Nationally%20Determined%20Contribution%20%28NDC%29_November2024.pdf)
- <sup>12</sup> De Gaspi, Renato H. 2024. Forging Alliances: Political Competition and Industrial Policy in Democratic Brazil Third World Quarterly Vol. 45, No. 5, pp. 981–1002. <https://doi.org/10.1080/01436597.2023.2283466>; De Gaspi, Renato H. 2024. Developmental Channels: (Incomplete) Development Strategies in Democratic Latin America. Regulation & Governance Vol.18, No.4, pp. 1210–31. <https://doi.org/10.1111/rego.12575>.
- <sup>13</sup> The mapping is the same for both missions in the sense that it looks at 'Inputs-Products-Markets'. The details of this mapping exercises has not been released yet.
- <sup>14</sup> [https://www.youtube.com/watch?v=bY9IS1\\_8IZA](https://www.youtube.com/watch?v=bY9IS1_8IZA)
- <sup>15</sup> <https://www.youtube.com/watch?v=9p3p5z5vNoY>
- <sup>16</sup> <https://www.gov.br/mdic/pt-br/assuntos/noticias/2024/dezembro/cndi-instala-gt-para-desenho-de-novas-cadeias-produtivas-no-ambito-da-nova-industria-brasil>; <https://www.in.gov.br/en/web/dou/-/resolucao-ce/cndi/mdic-n-6-de-29-de-outubro-de-2024-594313857>
- <sup>17</sup> [https://www.gov.br/gestao/pt-br/assuntos/comissao-interministerial-de-contratacoes-publicas-para-o-desenvolvimento-sustentavel/RESOLUCAO\\_SEGES\\_CICS\\_MGI\\_N\\_2\\_DE\\_2\\_DE\\_JULHO\\_DE\\_2024\\_RESOLUCAO\\_SEGES\\_CICS\\_MGI\\_N\\_2\\_DE\\_2\\_DE\\_JULHO\\_DE\\_2024\\_DOU\\_Imprensa\\_Nacional.pdf](https://www.gov.br/gestao/pt-br/assuntos/comissao-interministerial-de-contratacoes-publicas-para-o-desenvolvimento-sustentavel/RESOLUCAO_SEGES_CICS_MGI_N_2_DE_2_DE_JULHO_DE_2024_RESOLUCAO_SEGES_CICS_MGI_N_2_DE_2_DE_JULHO_DE_2024_DOU_Imprensa_Nacional.pdf); <https://agenciagov.ebc.com.br/noticias/202409/esther-dweck-destaca-avancos-em-contratacoes-publicas-e-transformacao-digital-do-estado-para-impulsionar-a-industria-brasileira>
- <sup>18</sup> De Gaspi, Renato H., and Pedro Perfeito Da Silva. 2024. "The Sectoral Politics of Industrial Policy Making in Brazil: A Polanyian Interpretation." *Development and Change* 55 (3): 398–428. <https://doi.org/10.1111/dech.12835>
- <sup>19</sup> [https://www.planalto.gov.br/ccivil\\_03/\\_ato2023-2026/2024/lei/114993.htm](https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/lei/114993.htm)
- <sup>20</sup> <https://normas.leg.br/?urn=urn:lex:br:federal:lei:2024-08-02:14948>
- <sup>21</sup> This type of coordination is crucial in democratic industrial policies, as shown by an emerging new academic literature. See, Bulfone, Fabio, Timur Ergen, and Erez Maggor. 2024. The Political Economy of Conditionality and the New Industrial Policy. Max Planck Institute Discussion Paper, 6.
- <sup>22</sup> <https://www.systemiq.earth/wp-content/uploads/2024/12/2024-12-10-EU-CRM-Innovation-Roadmap-vFinal-1.0-1.pdf>
- <sup>23</sup> <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-government-investing-25m-in-brazilian-nickel-cobalt-project-8211-ft-60603071>
- <sup>24</sup> <https://www.mining.com/sigma-lithium-project-in-brazil-just-got-27-bigger/>
- <sup>25</sup> <https://www.mining.com/sigma-lithium-receives-preliminary-approval-for-grota-do-cirilo-funding/>
- <sup>26</sup> US Geological Survey. 2024. Mineral Commodities Summary. <https://pubs.usgs.gov/periodicals/mcs2024/mcs2024.pdf>
- <sup>27</sup> <https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/061423-appian-seeks-location-for-brazil-graphite-processing-supercycle-continues-ceo>; <https://www.southstarbattery.com/2021/06/29/south-star-battery-metals-announces-positive-production-of-battery-grade-coated-spherical-purified-graphite/>
- <sup>28</sup> <https://carnegieendowment.org/2023/05/03/friendshoring-critical-minerals-what-could-u.s.-and-its-partners-produce-pub-89659>
- <sup>29</sup> Bloomberg New Energy Finance. 2023. Electric Vehicle Outlook.
- <sup>30</sup> <https://www.gov.br/mme/pt-br/assuntos/secretarias/geologia-mineracao-e-transformacao-mineral/pnm-2050/sobre-o-pnm-2050>
- <sup>31</sup> The following 'strategic minerals' have been selected as: Aluminum, Cobalt, Copper, Tin, Graphite, Lithium, Manganese, Platinum Group Metals (PGMs), Molybdenum, Niobium, Nickel, Silicon, Tantalum, Rare Earths, Titanium, Tungsten, Uranium, Vanadium and Zinc. See: <https://www.gov.br/mme/pt-br/assuntos/noticias/fundo-de-minerais-criticos-deve-destinar-ate-r-1-bilhao-para-pesquisa-de-minerais-estrategicos-para-a-transicao-energetica-e-seguranca-alimentar>



- <sup>32</sup> <https://www.gov.br/secom/pt-br/assuntos/obrasilvoltou/desenvolvimento/conselho-nacional-de-politica-mineral-cnpm-e-restruturado>; <http://www.finep.gov.br/chamadas-publicas/chamadapublica/753>; <https://www.gov.br/mme/pt-br/assuntos/secretarias/geologia-mineracao-e-transformacao-mineral/pnm-2050/sobre-o-pnm-2050>
- <sup>33</sup> <https://inventuspower.com/capabilities/brazil-solutions/>  
<https://www.borgwarner.com/newsroom/press-releases/2022/11/28/borgwarner-announces-battery-systems-factory-in-brazil>
- <sup>34</sup> There is expected to be over 8000GWh of capacity for demand totalling 4000 GWh in 2030. See: Bloomberg New Energy Finance. 2024. Long-term EV Outlook; [https://transitionaccelerator.ca/wp-content/uploads/2023/05/A-Roadmap-for-Canadas-Battery-Value-Chain\\_FULLL.pdf](https://transitionaccelerator.ca/wp-content/uploads/2023/05/A-Roadmap-for-Canadas-Battery-Value-Chain_FULLL.pdf); <https://www.energypolicy.columbia.edu/publications/the-ira-and-the-us-battery-supply-chain-background-and-key-drivers/>
- <sup>35</sup> <https://agenciabrasil.ebc.com.br/radioagencia-nacional/economia/audio/2024-07/imposto-sobre-importacao-de-carro-eletrico-aumenta-para-18>
- <sup>36</sup> [https://www.swissinfo.ch/por/bndes-aprova-financiamento-de-r\\$304-mi-para-volkswagen-no-brasil/87631556](https://www.swissinfo.ch/por/bndes-aprova-financiamento-de-r$304-mi-para-volkswagen-no-brasil/87631556)
- <sup>37</sup> Mercedes kept some of its operations for buses and trucks.  
<https://media.ford.com/content/fordmedia/fna/us/en/news/2021/01/11/ford-advances-south-america-restructuring.html>; <https://www.reuters.com/business/autos-transportation/mercedes-benz-lay-off-3600-workers-brazil-2022-09-06/>.
- <sup>38</sup> <https://valorinternational.globo.com/business/news/2024/03/07/analysis-brazil-remains-one-of-the-worlds-biggest-vehicle-producers.ghtml>
- <sup>39</sup> <https://www.autodata.com.br/noticias/2024/10/21/toyota-e-renault-colocam-as-suas-fichas-nos-hibridos-flex/79453/>
- <sup>40</sup> FENABRAVE. 2024. Informativo FENABRAVE - Dezembro 2024.
- <sup>41</sup> <https://robbieandrew.github.io/carsales/>
- <sup>42</sup> <https://www.gov.br/planalto/pt-br/acompanhe-o-planalto/noticias/2024/04/presidente-lula-reforca-estimulo-a-industria-automotiva-que-investira-r-125-bi-no-brasil-ate-2033>
- <sup>43</sup> This has been pointed since the 1970s. See: Evans, Peter. 1979. Dependent Development: the alliance of multinational, state, and local capital in Brazil.
- <sup>44</sup> <https://www.cnnbrasil.com.br/auto/imposto-de-35-sobre-eletricos-atende-veiculos-a-combustao-e-frustra-planos-de-baixa-emissao-diz-setor/>
- <sup>45</sup> [https://liffenergy.gov/wp-content/uploads/2024/11/Pathways-to-Commercial-Liftoff\\_Sustainable-Aviation-Fuel.pdf](https://liffenergy.gov/wp-content/uploads/2024/11/Pathways-to-Commercial-Liftoff_Sustainable-Aviation-Fuel.pdf); <https://modern diplomacy.eu/2024/08/22/chinas-new-policy-on-sustainable-aviation-fuel-saf-a-step-towards-greener-future/>
- <sup>46</sup> <https://rsb.org/wp-content/uploads/2021/04/RSB-SAF-Feedstock-availability-in-Brazil.pdf>; <https://fapesp.br/publicacoes/flighpath-to-aviation-biofuels-in-brazil-action-plan.pdf>
- <sup>47</sup> <https://rsb.org/wp-content/uploads/2021/04/RSB-SAF-Feedstock-availability-in-Brazil.pdf>
- <sup>48</sup> Bloomberg New Energy Finance. 2024. Global Renewable Fuels Projects Tracker. Brasil BioFuels plant in North Brazil is expected to have a SAF production capacity of 280 million liters per year. SAF buyers are expected to be LatAm, Gol, Azul  
<https://www.spglobal.com/commodityinsights/es/oil/refined-products/jetfuel/051822-brazil-saf-mandate-to-target-emissions-reductions-starting-in-2027>
- <sup>49</sup> <https://www.agweb.com/markets/pro-farmer-analysis/shell-backed-ethanol-firm-considers-making-saf-brazil>
- <sup>50</sup> Bloomberg New Energy Finance. 2024. Sustainable Aviation Fuel Outlook.
- <sup>51</sup> <https://www.spglobal.com/commodityinsights/es/oil/refined-products/jetfuel/051822-brazil-saf-mandate-to-target-emissions-reductions-starting-in-2027>
- <sup>52</sup> <https://www.cnnbrasil.com.br/economia/negocios/brasil-estima-produzir-16-bi-de-litros-de-combustivel-sustentavel-de-aviacao/>
- <sup>53</sup> <https://www.bloomberg.com/news/articles/2024-10-31/big-oil-sees-brazil-becoming-major-global-hub-for-clean-jet-fuel>

- <sup>54</sup> <https://valor.globo.com/empresas/noticia/2023/12/31/petrobras-compra-tecnologia-para-produzir-bioquerosene-de-aviacao-e-diesel-renovavel-com-oleo-de-soja-e-sebo-bovino.shtml>
- <sup>55</sup> <http://www.finep.gov.br/chamadas-publicas/chamadapublica/746>;  
<https://valor.globo.com/publicacoes/especiais/revista-inovacao/noticia/2024/12/19/empresas-aceleram-para-produzir-combustivel-sustentavel-de-aviacao-em-2027.shtml>
- <sup>56</sup> Bloomberg New Energy Finance. 2024. 2023 Global Wind Turbine Market Shares: Boom in China.
- <sup>57</sup> NZIPL Data from company announcements.
- <sup>58</sup> [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/GWEC/GWEC\\_Brazil.pdf?la=en&hash=536D559594CEC6820C897026415CA78287726696](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2013/GWEC/GWEC_Brazil.pdf?la=en&hash=536D559594CEC6820C897026415CA78287726696)
- <sup>59</sup> <https://www.bloomberg.com/news/articles/2012-12-13/bndes-raises-local-content-requirement-for-brazil-wind-turbines>; <https://www.bloomberg.com/news/articles/2012-08-09/rousseff-solar-push-thwarted-by-bndes-loan-ban-corporate-brazil>
- <sup>60</sup> Bazilian, Morgan, Victoria Cuming, and Thomas Kenyon. 2020. Local-content rules for renewables projects don't always work Energy Strategy Reviews Volume 32, 100569.  
<https://www.sciencedirect.com/science/article/pii/S2211467X2030122X>
- <sup>61</sup> Bazilian et al, p. 4.
- <sup>62</sup> Ferraz, João Carlos, Luma Ramos, and Bruno Plattek. 2022. Development finance innovations and conditioning factors: The case of the Brazilian Development Bank and sustainable industries Brazilian Journal of Political Economy, Vol. 42, No. 4, pp. 977–997.  
<https://www.scielo.br/j/rep/a/tB5zt8v5XzhT9Mfjnk5FRFC/?lang=en>
- <sup>63</sup> WEG. 2024. Manufacturing Sites.  
[https://static.weg.net/medias/downloadcenter/h53/hde/50022688\\_english\\_web.pdf](https://static.weg.net/medias/downloadcenter/h53/hde/50022688_english_web.pdf)
- <sup>64</sup> <https://valor.globo.com/publicacoes/suplementos/noticia/2022/06/30/importacao-de-equipamentos-encarece-projetos.shtml>
- <sup>65</sup> This is a generalized problem for Brazilian exports, see: Fall, Falilou, Fialho, Priscilla, & Huang, Tony. 2024. Scaling-up infrastructure investment to strengthen sustainable development in Brazil. OECD Economics Department Working Papers 1790.
- <sup>66</sup> Wang, Zhan, Geraldo Martha Jr., Jing Liu, Cicero Lima, Thomas Wertel. 2024. Planned expansion of transportation infrastructure in Brazil has implications for the pattern of agricultural production and carbon emissions.
- <sup>67</sup> Santos, Rosana. E+.
- <sup>68</sup> <https://www.gov.br/mdic/pt-br/assuntos/noticias/2023/dezembro/recomposicao-tarifaria-estimula-producao-nacional-de-paineis-solares-e-aerogeradores>;  
<https://renewablesnow.com/news/bndes-finances-development-of-7-mw-onshore-wind-turbine-by-weg-822816/>
- <sup>69</sup> <https://www.gov.br/mdic/pt-br/assuntos/noticias/2024/junho/relatorio-do-gt-de-energia-eolica-com-propostas-para-o-setor-e-encaminhado-a-casa-civil>
- <sup>70</sup> <https://emasenergia.org/artigo-de-opinioao/emendas-ao-pl-576-21-ameacam-protagonismo-do-pais-na-transicao-energetica/>
- <sup>71</sup> <https://www.cnnbrasil.com.br/politica/lula-veta-jabutis-do-setor-eletrico-no-pl-das-eolicas-offshore/>
- <sup>72</sup> World Bank. 2024. Scenarios for Offshore Wind Development in Brazil. It is worth noting that the radar methodology in this report (see Figure 1) does not account for offshore wind potential. Brazilian potential is a lot greater when that is accounted for. See Annex for the full methodology.
- <sup>73</sup> Allan, Bentley and Jonas Nahm. 2024. Strategies of green industrial policy: how states position firms in global clean energy supply chains. American Political Science Review.  
<https://doi.org/10.1017/S0003055424000364>
- <sup>74</sup> Bataille, Chris, Seton Stiebert, and Francis G. N. Li. 2024. Facility level global net-zero pathways under varying trade and geopolitical scenarios. Global Energy Monitor. <http://netzerosteel.org>.
- <sup>75</sup> Bataille et al 2024, 44.
- <sup>76</sup> Bataille et al 2024, 7.

<sup>77</sup> Relva, Stefania, Clauber Leite, Rosana Santos, Fabian Barrera, Leandro Janke, Karina Marzano, Camilla Oliveira, Kathrin Gretener, Bruno Naredo, Ennio Peres da Silva, and Jorge Boeira. 2024. 12 Insights sobre Hidrogênio. Joint report from E+, Agora Industry, and Cognitio Consultoria.

<sup>78</sup> Kumar, Manoj and Ohri Nikunj. 2024. "India Sees EU Carbon Tax Proposal as Unfair and Not Acceptable, Official Says." Reuters <https://www.reuters.com/world/india/india-sees-eu-carbon-tax-proposal-unfair-not-acceptable-official-says-2024-07-29/>.

<sup>79</sup> E+. 2024. Strategies for Strengthening Green Iron and Steel Trade Agreements

<sup>80</sup> Global Energy Monitor. 2024. Forging a sustainable future: Brazil's opportunity to lead in steel decarbonization.

<sup>81</sup> <https://agenciadenoticias.bndes.gov.br/detalhe/noticia/BNDES-aprova-primeira-operacao-de-carvao-vegetal-do-Fundo-Clima/>

<sup>82</sup> <https://vale.com/w/vale-advances-on-mega-hubs-project-by-signing-off-take-agreement-with-essar-group-to-supply-iron-ore-agglomerates>

<sup>83</sup> <https://eixos.com.br/hidrogenio/incentivos-para-hidrogenio-devem-olhar-fabricantes-nacionais-de-equipamentos-defende-hytron/>; <https://www.gov.br/mme/pt-br/assuntos/noticias/alexandre-silveira-destaca-vanguarda-do-pais-em-inauguracao-de-centro-de-hidrogenio-verde>

<sup>84</sup> This is particularly important given the structural difficulties for scrap collectors. See: <https://oeco.org.br/reportagens/porque-o-brasil-recicla-somente-um-quarto-de-sucata-ferrosa-e-a-cadeia-opera-na-ociosidade/>; <https://valorinternational.globo.com/business/news/2024/09/20/dismantling-oil-platforms-could-generate-r300bn.ghtml>

<sup>85</sup> <https://www.gov.br/mdic/pt-br/assuntos/camex/atas-e-resolucoes/gecex/extratos/deliberacoes-da-219a-reuniao-ordinaria-do-comite-executivo-de-gestao-gecex-1>

<sup>86</sup> <https://eixos.com.br/transicao-energetica/governo-defende-aco-verde-como-carro-chefe-para-brasil-ganhar-mercado-internacional/>

<sup>87</sup> <https://oec.world/en/profile/bilateral-product/fertilizers/reporter/bra>

<sup>88</sup> <https://www.czapp.com/analyst-insights/green-hydrogen-law-a-boon-for-brazilian-agribusiness/>

<sup>89</sup> <https://www.atlasagro.ag/atlas-agros-uberaba-green-fertilizer-project-selected-to-join-global-effort-to-decarbonize-accelerate-industrial-energy-transition/>

<sup>90</sup> <https://www.icis.com/explore/resources/news/2024/10/31/11046102/atlas-agro-and-casa-dos-ventos-to-develop-green-fertilizer-project-in-brazil/>

<sup>91</sup> H2Orizonte Verde Project – CSN Group (RJ); DRHy – EDP Renováveis Brasil (CE); Camaçari H2V HUB – Neoenergia (BA); Uberaba Green Fertilizer (UGF) – Atlas Agro (MG); Hydrogen Hub – São Paulo – Petrobras (SP); H2 Açú Hub – Prumo Logística (RJ); B2H2 – Copel GET (PR); H2AL-BRUK – Solatio Holding Solar Project Management (SP); Cubatão H2V Hub – Eletrobras (SP); Hydrogen and Ammonia Hub in MG – Cemig Generation and Transmission (MG); H2V Project – Ecohydrogen Energy (BA); Suape TE HUB – Suape Industrial Port Complex (PE)

<https://fuelcellworks.com/2025/01/01/news/brazil-mme-announces-the-selection-f-12-projects-for-the-creation-of-hydrogen-hubs>

<sup>92</sup> <https://eixos.com.br/hidrogenio/brasil-precisa-avancar-na-regulacao-do-hidrogenio-para-viabilizar-producao-de-fertilizantes-verdes-diz-diretora-do-bndes/>

<sup>93</sup> <https://exame.com/agro/camex-mantem-tarifa-sobre-importacao-de-fertilizante-isenta/>

<sup>94</sup> [https://portal.apexbrasil.com.br/regulatory\\_report/the-federal-government-enacted-the-2022-2050-national-fertilizer-plan-seeking-to-reduce-the-brazilian-dependency-on-imported-fertilizers-currently-supplying-more-than-80-of-demand-among-its-goals/](https://portal.apexbrasil.com.br/regulatory_report/the-federal-government-enacted-the-2022-2050-national-fertilizer-plan-seeking-to-reduce-the-brazilian-dependency-on-imported-fertilizers-currently-supplying-more-than-80-of-demand-among-its-goals/)

<sup>95</sup> Gomes, Ieda, Aliaksei Patonia, Agustín Gogorza, Luciano Caratori, Hernan Carlino, Nathalia Gama, Luis Diazgranados, Nuria Hartmann, and Hans Kulenkampff. 2024. Hydrogen for the 'Low Hanging Fruits' of South America: Decarbonising Hard-to-Abate Sectors in Brazil, Argentina, Colombia, and Chile. OIES Paper ET 33. Oxford: The Oxford Institute for Energy Studies.

<sup>96</sup> <https://www.worldfertilizer.com/project-news/16082024/petrobras-starts-reactivation-process-for-fertilizer-plant-in-araucaria-parana-state/>

<sup>97</sup> <https://agencia.petrobras.com.br/en/w/negocio/petrobras-e-embrapa-assinam-cooperacao-para-pesquisas-em-produtos-de-baixo-carbono-e-fertilizantes>

- <sup>98</sup> <https://brazilenergyinsight.com/2024/11/18/petrobras-and-yara-sign-agreements-for-technical-cooperation-and-industrialization-of-arla-32/>
- <sup>99</sup> This section offers preliminary suggestions on workforce training, education, and innovation. The Lab intends to address these topics in greater detail in future work.
- <sup>100</sup> <https://www.portaldaindustria.com.br/canais/observatorio-nacional-da-industria/produtos/mapa-do-trabalho-industrial-2025-2027/>
- <sup>101</sup> OECD. 2022. Engaging Employers in Vocational Education and Training in Brazil: Learning from International Practices. <https://doi.org/10.1787/d76a2fe6-en>
- <sup>102</sup> <https://www.folhape.com.br/colunistas/blogdafolha/lula-sanciona-o-marco-legal-do-ensino-tecnico-projeto-de-joao-campos/38889/>
- <sup>103</sup> <https://www.gov.br/mec/pt-br/pnept>
- <sup>104</sup> <https://agenciagov.ebc.com.br/noticias/202403/lula-e-com-a-educacao-que-a-gente-vai-ser-um-pais-de-primeiro-mundo>
- <sup>105</sup> <https://embrapii.org.br/en/unidades-embrapii/>
- <sup>106</sup> [https://www.gov.br/inpi/pt-br/inpi-data/indice-brasil-de-inovacao-e-desenvolvimento-ibid/IBID2024\\_ENfinal.pdf](https://www.gov.br/inpi/pt-br/inpi-data/indice-brasil-de-inovacao-e-desenvolvimento-ibid/IBID2024_ENfinal.pdf)
- <sup>107</sup> Mais Inovação Brasil has R\$61 billion available until 2026. R\$41 billion is for TR-rate credit lines, R\$21 billion from BNDES and R\$20 billion from Finep. Finep is also making available another R\$20 billion in non-refundable form. <https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2023/08/mcti-vai-aportar-r-41-bilhoes-no-programa-mais-inovacao-brasil>
- <sup>108</sup> Stiglitz, Joseph and Dani Rodrik. 2024. A new growth strategy for developing nations. <https://drodrik.scholar.harvard.edu/publications/new-growth-strategy-developing-nations>
- <sup>109</sup> Stiglitz and Rodrik 2024, 12.
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- <sup>111</sup> Perez 2017, 362.
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