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JUST ENERGY TRANSITION IN BRAZIL

UNRISD UNITED NATIONS RESEARCH INSTITUTE FOR SOCIAL DEVELOPMENT

Research for Social Change

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List of Acronyms

ABEEólica	Associação Brasileira de Energia Eólica (Brazilian wind energy association)
ANEEL	Agência Nacional de Energia Elétrica (Brazilian Electricity Regulatory Agency)
BNDES	Brazilian National Development Bank
CFEM	Financial Compensation for Exploitation of Mineral Resources
Embrapa	Empresa Brasileira de Pesquisa Agropecuária (Brazilian agricultural research agency)
EPE	Empresa de Pesquisa Energética (Energy Research Agency)
EV	electric vehicle
FINEP	Financiadora de Estudos e Projetos (Funding Authority for Studies and Projects)
GDP	gross domestic product
GHG	greenhouse gas
GWM	Chinese Great Wall Motors
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of the Environment and Renewable Natural Resources)
IRENA	The International Renewable Energy Agency
MAB	Movimento dos Antingidos por Barragens (Movement of those Affected by Dams)
MST	Movimento dos Trabalhadores Rurais Sem-Terra (Landless Workers Movement)
MNC	Multinational Company
NIP	New Industrial Policy

Executive Summary

To speak of a *just* energy transition means reducing inequality as fossil fuel sources are replaced with low-carbon ones, with a special emphasis on both addressing impacts on workers, host communities, and vulnerable groups and including them in decision-making on their fates. Surveying a just energy transition in Brazil starts from a conceptual definition like this one, but also needs to reflect on the country's national characteristics and energy history. This report addresses three questions: The first question discusses multiple kinds of energy in Brazil with the aim of identifying how much and what kind of energy transition is actually happening. As in many countries, energy transition in Brazil is uneven and partial, with oil and gas production continuing to grow alongside new low-carbon energy sources. The second question focuses on the justice issues that arose with the historical *status quo* of Brazil's energy sector before turning to the third question of the justice dimensions of the transition itself.

This report illustrates how the energy transition is still incipient in Brazil, especially if transition means actually reducing oil and gas production. In addition, and unfortunately, there is no form of energy in Brazil that is free from negative socioenvironmental and developmental impacts that might present an energy injustice. However, different kinds of energy present different constellations of impacts on different people, including different vulnerable groups of people. Thus, thinking about a just energy transition requires thinking of this bundle of impacts, of both new sources of energy and existing ones. Despite challenges, Brazil retains considerable scope for action to achieve its climate and development aims in a way that is more just rather than less so. And in the context of international initiatives like the COP30 in Belem, Brazil can take steps that start to rejuvenate an ailing climate multilateralism that pushes back at the pressures that are deepening inequality and injustice both globally and within countries.

Introduction

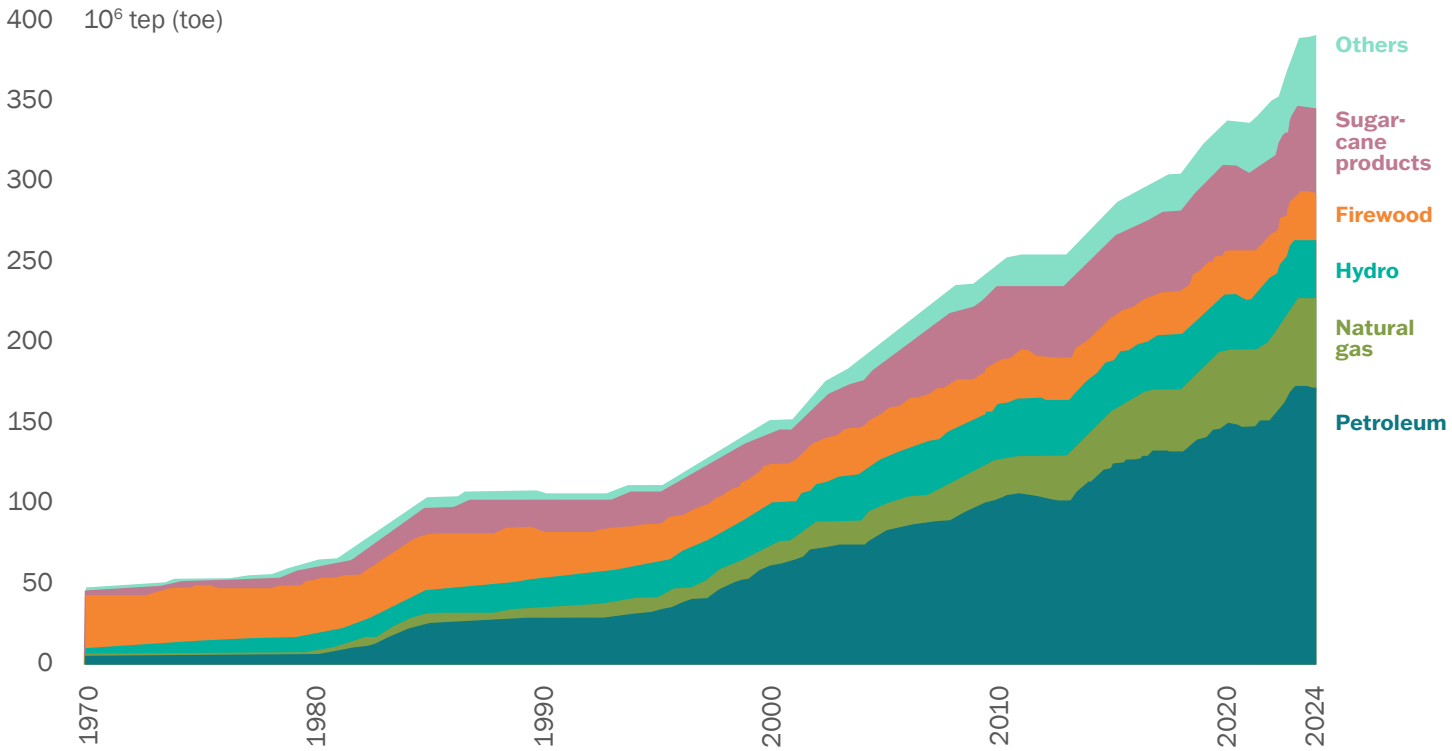
Minas Gerais, Brasil. Photo by Studio Michael França (public domain).

In its simplest terms, an energy transition means replacing high-carbon energy sources with low-carbon ones. This changeover is critical for reducing the greenhouse gas (GHG) emissions that cause climate change, as energy-based emissions form a large share of most countries' total GHG emissions. However, the simple physical changeover of energy sources brings with it many associated socio-economic changes because energy is woven through the whole national political economy. To speak of a *just* energy transition means reducing inequality as fossil fuel sources are replaced with low-carbon ones, with a special emphasis on both addressing impacts on workers, host communities, and vulnerable groups and including them in decision-making on their fates.

Surveying a just energy transition in Brazil starts with these shared definitions, but also needs to reflect its national characteristics and energy history. Notably, Brazil has long had very high levels of socioeconomic inequality, with strong regional and racial patterning, even as inequality has generally declined in this century. Different sources of energy involve different regions and peoples of this fifth-largest country in the world, intersecting with the patterns of inequality. Brazil is a powerhouse of biodiversity, forests, and freshwater, also distributed unequally across the country, and those should not be sacrificed for decarbonization (EPE 2024a:403). Next, Brazil's energy matrix has historically been one of the lowest in carbon intensity in the world: hydropower has dominated the electricity sector and extensive use of bio-fuels like sugar-cane based ethanol have reduced transport emissions. While Brazil is now a major producer of oil and gas, most of that production is recent (see Figure 1). Finally, the Brazilian state has been a very active player in the energy sector, not just as a regulator but as a major producer itself and through its support for innovation and industrial development in the sector. Development concerns are always present.

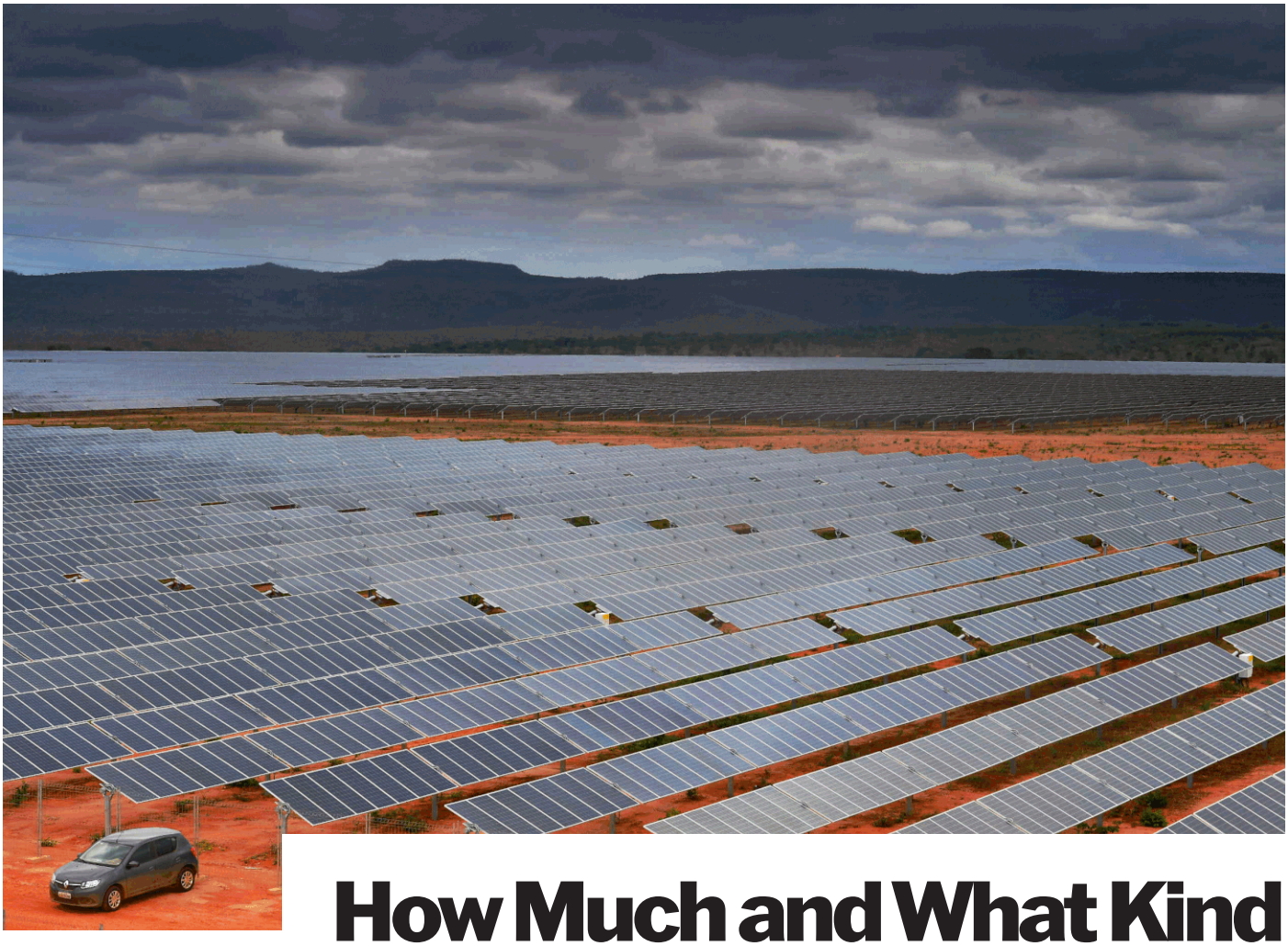
Keeping these characteristics in mind, this report addresses three questions

Figure 1. Primary energy production, 1970-2024



Source: EPE 2025:17.

in sequence before presenting a final summary of the most difficult tradeoffs and areas for debate that remain. The first question discusses multiple kinds of energy in Brazil with the aim of identifying how much and what kind of energy transition is actually happening. As in many countries, energy transition in Brazil is uneven and partial, with oil and gas production continuing to grow alongside new low-carbon energy sources. The second question focuses on the justice issues that arose with the historical *status quo* of Brazil's energy sector before turning to the third question of the justice dimensions of the transition itself.



Pirapora solar power plant. Photo by Carl de Souza/AFP (CC BY-SA 4.0).

How Much and What Kind of Energy Transition is Happening in Brazil?

Answering this question requires knowing something of the history of different energy sources in Brazil, as well as their trajectories of growth and/or decline. This summary cannot be comprehensive, but focuses on the largest and most-impactful energy sources as well as briefly discussing emerging niches in the energy system.[1] The role of state planning and investment is an important part of the story, especially after the creation of the parastatals Petrobras (1953) and Eletrobras (1962) to develop petroleum and electricity, respectively. State management has waned as partial privatizations and institutional reforms starting in the 1990s removed many of Eletrobras' functions and introduced private capital to both, and finally Eletrobras was fully privatized in 2021. Nonetheless, the Brazilian state still continues to exercise considerable control over planning and governance in the sector and largely controls the pace and orientation of any energy transition. Brazilian decision-makers in the Ministry of Energy adopted the first National Plan for Energy Transition only in August, 2024 (MME 2024). Even so, many changes have been underway since the turn of the century despite the lack of a comprehensive plan, guided in part through the annual decadal planning documents of the Energy Research Agency (*Empresa de Pesquisa Energética*, EPE).[2]

1 Coal and nuclear power, for example, are both present in Brazil but in comparatively small quantities. Brazil does not plan to phase out or greatly expand either, so they are not discussed.

2 For example, EPE 2024a. The 2010 regulation of the 2009 National Climate Law designated EPE and its annual planning documents as the primary implementing mechanism for climate action in the energy sector.

As Figure 1 showed, *oil and gas* production began slowly in Brazil, accelerating as Petrobras developed strategies for off-shore production in the Campos Basin from the 1970s (Morais 2013). This experience allowed it to lead a constellation of producers when very large and very deep reserves were discovered in 2006, in what is known as the pre-salt region. Oil and gas now form the largest share of Brazilian primary energy production, with growth accelerating after 2000. Gas production grew as a byproduct of the growth of oil, but also received new impetus as the system stabilizer for increased wind and solar power (Coalizão Energia Limpa 2024; Hochstetler 2021). Without new exploration, current reserves would reach peak production at 5 million barrels/day of oil in 2030 and decline to 4 million by 2034. Gas would peak a year later (EPE 2024a:194;199). Currently, 76 percent of oil production and 75 percent of gas production are in the pre-salt region, deep off-shore from the heavily-populated Southeast region (EPE 2024a:196). On-going exploration towards production, which would be primarily in the Equatorial Margin, is seen as necessary for energy security and economic development (EPE 2024a:197). The Equatorial Margin as a whole is nearer to the Amazon region in the North and Northeast, and its most promising areas are in the Foz do Amazonas (Mouth of the Amazon) Basin. The environmental licensing agency IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) has just granted a first environmental license for the area near the mouth of the Amazon River. The National Petroleum Agency auctioned pre-license contracts for exploration in 172 oil and gas blocks in June, 47 of them in the Mouth of the Amazon (Couto 2025). Bidders signed contracts on only 34 blocks, 19 in the Amazon, giving the government $181 million in signing bonuses, with 85 percent of the funds in the Mouth of the Amazon. Consortia led by Petrobras and Exxon will lead operations in ten, while another led by Chevron acquired nine (Teixeira et al. 2025).

Hydropower has been the incumbent fuel of Brazil's electricity sub-sector, starting with private foreign capital in the nineteenth century near Brazil's big cities in the Southeast before becoming the focus of state development efforts in the 1950s. Domestic construction firms acquired the skills to build steadily larger dams and turbines, constructing almost 100 large plants per decade in the 1950s to 1970s (Khagram 2004:144). Once international finance for these big dams disappeared after 1990 as their socioenvironmental impacts became clearer, the Brazilian National Development Bank (BNDES) eventually stepped in, financing the building of 41 large (over 30MW) hydroelectric plants from 2002-2012 (BNDES 2025). In 2006, the Energy Research Agency produced a planning document that identified 40 more large hydroelectric plants that could be built, mostly in the Amazon region (EPE 2006:281; Hochstetler 2021). Besides the giant Belo Monte hydroelectric plant, ensnared in mobilized opposition and a decade of court challenges to its licensing before finally being built in reduced form, most of these remain as plans on paper, unrealized. As Figure 1 shows, the quantity of hydroelectric power has remained largely static for the last twenty years. The latest plans show only more optimized use of existing plants, with just 118MW in one new proposed plant in Paraná, a state in the South (EPE 2024a:106-109). Logistical considerations like hydropower's vulnerability to drought are part of the reason for the pause, but the socioenvironmental justice

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Itaipu Hydroelectric Power Plant, Paraná River. Photo by Deni Williams (CC BY 2.0).

concerns discussed in the next section also provide part of the answer as to why.

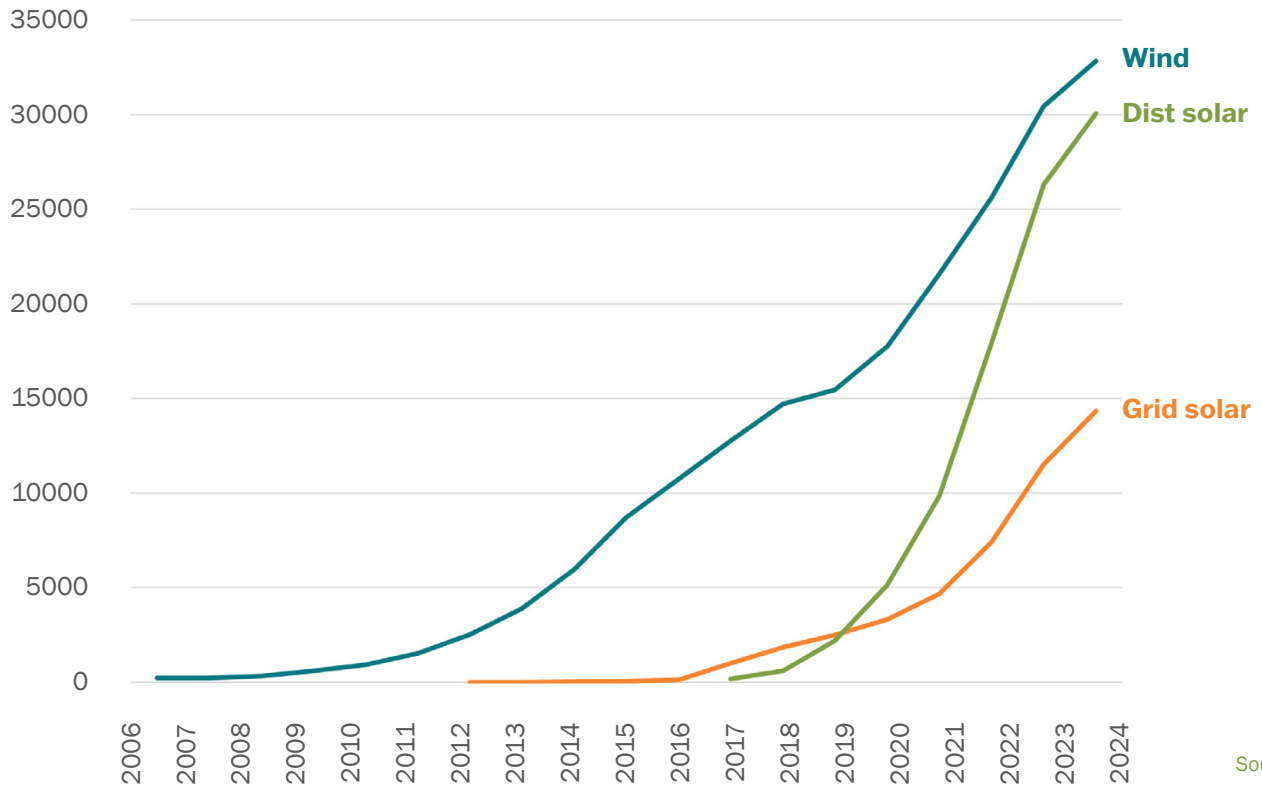
Biofuels are another long-time part of the Brazilian energy matrix, with regular innovations and state support for expansion that is visible in Figure 1. State-driven industrial policy from 1975 to 1990 was part of Brazil's response to the oil price crises of that decade (Leite 2009). The National Alcohol Program, Proálcool, was run by Petrobras and national energy agencies, using sugarcane to build, "the single largest oil-substitution and renewable energy program in the world" (Rogers 2022:3-6). Embrapa (Empresa Brasileira de Pesquisa Agropecuária), the state agricultural research agency, also led innovation in soy-based biodiesel. Private actors led innovation on the demand side, developing alcohol-only cars in the early 1980s and then flex-fuel cars that could run on either gasoline or alcohol or both in 2003. As Proálcool ended, regulations continued to be supportive but less comprehensive and long-term, so the market appeal of the flex-fuel cars spurred a biofuels industry that had been waning. Some of the post-Proálcool regulations have targeted agricultural field-based productivity, while others promoted experiments with different fuel types and sources (Aguiar 2025; Fraundorfer and Rabitz 2020). Sugarcane is a comparatively efficient first-generation biofuels source (Elbehri et al. 2013), but BNDES, Embrapa, and FINEP (Financiadora de Estudos e Projetos), the national innovation agency, have been working together over decades to develop second- and third-generation biofuels. The 2017 Renovabio programme incentivized more production and use of biofuels through a programme that gave producers carbon credits if they could show that they were decarbonizing production and required fuel distributors to meet their own decarbonization targets through these certificates. The 2024 "Fuel of the Future" programme gradually increases the green blends required in diesel, ethanol, natural gas, and sustainable airline fuels, aiming for R$250 billion in investments in these and carbon capture and storage initiatives (Wallendorf 2024). As this dense summary makes clear, Brazil has had a fifty-year commitment to develop and expand biofuels that the country expects to continue well into the future.

Wind and solar power are the heart of most decarbonizing energy transitions and often grow together in national energy transition strategies. As Figure 2 shows, however, wind and solar power have been on different trajectories in Brazil, with grid-scale wind power rising first, grid-scale solar power

coming more slowly and on a smaller scale, and distributed (household level) solar power arising very late and very quickly to match the scale of wind power. The first plans for wind power date back to 2002, following a severe drought the prior year that showed the hydropower system's vulnerability. A feed-in tariff programme called Proinfa called for building 1100 MW each of wind, small hydro, and biomass-based electricity to diversify the electricity supply. Solar was excluded as too expensive at the time. Wind was also favored by economists in the Ministry of Energy who calculated that Brazil had the resources and expertise to build a domestic wind industry, including for inputs and construction, which could counter-balance higher electricity costs (Hochstetler 2021:65). Starting in 2009, competitive auctions were used to commission most of the eventual installed capacity of wind power, now nearly 35,000 MW. The first auction for grid-scale solar power was added only in 2014, when global solar cell prices had dropped considerably. Thus, the addition of wind and solar power in national planning for grid-scale electricity supply was very responsive to their costs of inputs and construction in Brazil, as well as their potential for providing incentives for a new industrial sector.

Distributed solar power has followed a different trajectory, with a larger role played by national regulation. The energy regulator, ANEEL (Agência Nacional de Energia Elétrica), began to adjust regulations for distributed generation in 2012, not for decarbonization (solar was not the only kind of electricity affected), but more to meet rural needs (Bradshaw 2018:144-150). More generous net-metering rules came in Regulation 687 of 2015, when only about 1000 distributed systems had been added.

Figure 2. Cumulative MW of installed capacity of wind and solar power, 2006-2024



Source: EPE 2025b.

These were followed by further expansion of distributed generation. When consultations on new rules reopened again in 2018, ANEEL no longer favored reduced grid connection charges for distributed solar power, which were contributing to new debates about the weight of these subsidies in the cost of electricity (Hochstetler 2021:168-169). ANEEL and distributors would have made consumers who installed distributed solar generation immediately pay the full cost of grid connection. Consumers and the solar industry shifted venues from the regulatory agency to the National Congress. They persuaded the Congress to pass Law 14,300 in 2022, which gave discounted access to the grid until 2045 for existing projects and those that would be built by the end of 2022, then gradually increasing the cost of network access. When President Lula da Silva returned to office the next year, he extended the grace period. This law and a regulation that allowed medium-scale consumers greater freedom to contract their own electricity supply—along with the continuing availability of cheap Chinese-produced equipment—unleashed the very fast rise in distributed solar power from 2021. One side effect of that very quick rise of a new supply of electricity is that demand for wind power has virtually disappeared, leaving both installers and manufacturers in the wind power supply chain with little to do.[3] In the last few years, then, these two low-carbon sources of electricity have become clear competitors with each other for space in the national electricity matrix, with solar power winning. However, a legal framework for off-shore wind power has passed the National Congress, which may give wind a new boost (Guerra et al. 2025:18, footnote 71).

Emerging green sectors: Following the 2015 Paris Agreement on climate change and in the recovery from Covid-19, many countries turned to green industrial policies to try to both grow and decarbonize their economies. Brazil was well-placed to succeed in this competition to decarbonize other sectors, in a process known as power-sharing, given its large supply of low-carbon electricity. However, it was governed first by a weak President Michel Temer overseeing economic and political crises (2016–2018) and then by Jair Bolsonaro (2019-2022), who was fiercely opposed to climate action and industrial policy. Some initiatives came from the private sector, but Brazil's systematic efforts to use its green energy to decarbonize other sectors and develop relevant inputs, like critical minerals, began only after Lula returned to office in 2023. As a result, the general picture in this area is of a series of new enabling regulations and laws, some of which have financial and other kinds of support through Brazil's Sustainable Taxonomy and its New Industrial Policy (NIP) (Guerra, et al. 2025; Ministério do Fazenda 2024a; Ministério do Fazenda 2024b). Three of the NIP's Missions are related to energy transition. There is less concrete achievement yet and it will depend in large part on who replaces Lula in 2027 as well as the larger geopolitics of trade in 2025 and beyond.

Green hydrogen plans are among the most advanced. The Low-Carbon Hydrogen Law (14,948) was passed in August of 2024. It follows a National Hydrogen Programme created in 2022 and is meant to promote the industry. Law 14,990 of the same year foresees billions of Brazilian Reais in annual credits for the industry (Observatório do Clima 2024:52). A year before the law was passed, private companies had signed already memorandums of agreement with the state governments that have a lot of wind power and other companies. Sixteen projects

[3] Interviews in July 2024 with representatives of ABEEeólica and ABSolar.

were underway, some of them pilot projects (Couto and Rosas 2023). Early investments are clustered in the Pecém Port Complex in the Northeastern state of Ceará, whose share totaled some 88 percent of USD 10 billion awaiting final investment decisions in 2026 (ABIHV 2025). One pilot project in green hydrogen was actually producing in 2024 and some construction for the future hub in Ceará was to begin by the end of the same year, the latter funded in part by a USD 90 million contract with the World Bank (Cunha 2024:11-13). The Pecém Port Complex promises to export green hydrogen based on wind and solar power beginning in 2025 and reaching exports of 1,290,053 ton/year in 2030 (Pecém Industrial and Port Complex 2021). Biofuels can also be used to produce green hydrogen. Possible industrial uses for the green hydrogen in Brazil would be green steel and green fertilizer. In *electric vehicles* (EVs), Brazil historically had a strong vehicle manufacturing industry that was winding down. It is now being revitalized by foreign manufacturers setting up production in the country, especially as import tariffs are raised (Guerra et al. 2025:11-13). BYD, the Chinese giant, first came to Brazil in 2015 to manufacture electric buses and has opened two EV manufacturing facilities. The Chinese Great Wall Motors (GWM) has just opened another EV manufacturing facility, after acquiring it from Daimler in 2021 (Carter 2025). With manufacturing costs in China just half those of Brazil's, even Brazil's high tariffs do not create ready competitiveness for expansion of EV production (Gelles et al. 2025; Olmos 2025). *If* Brazil can expand its extraction of *critical minerals* for the green transition and *if* it can process those domestically and *if* it can then produce *batteries*, the landscape for EV and other related production in Brazil could grow further. Brazil currently, "has 15GW of battery production capacity, about 1.2 percent of global capacity in 2023" (Guerra et al. 2025:10). This is also primarily production by multinational companies (MNCs), although there are pilot projects arising from Brazil's innovation initiatives (Olmos 2024). On the *critical minerals* themselves, the Minister of Mines and Energy said he expects Brazil to announce a national critical minerals strategy—including lithium, copper, niobium, cobalt, and rare earths—in 2025 to support investments and sustainable production (Zaparolli 2025). It will be supported by funds from BNDES and FINEP designed for R&D and start-ups in the area (Guerra et al. 2025:8-9).

In summary, Brazil presents a mixed picture on how much energy transition is currently underway. New sources of energy like wind and solar power have expanded quickly over the last decade, adding new renewable energy capacity to a national energy matrix that already had a great deal of hydropower and biofuels. These provide a basis for growing power-sharing, or new sectors that can make use of Brazil's comparatively clean and low-carbon electricity sector. However, hydropower, the historic mainstay of the electricity system, is no longer expanding. At the same time, oil and gas production is expanding faster than any other source, so there is limited overall decarbonization of the energy sector taking place. This complex picture requires looking at the multiple sources of both the *status quo* energy sources and the new ones to understand the socioenvironmental and developmental impacts relevant to a just—or unjust—energy system.

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Illegal deforestation in the Pirititi Indigenous Territory, Roraima
Photo by Ibama (CC BY-SA 2.0).

Environmental Justice Issues Associated with Brazil's Status Quo Energy Matrix

Studies of the justice implications of energy transition often focus primarily on the impacts of new forms of energy, but the socioenvironmental and developmental impacts of the historical energy matrix also carry significant implications for a just energy transition. This section focuses on the justice dimensions of three particularly important historical energy sources: oil and gas, biofuels, and hydropower. As just outlined, current Brazilian energy planning foresees an ongoing and growing role for the first two. Little new hydropower is planned, but the existing installed capacity will continue to be used and optimized.

As a backdrop to all of the subsequent discussions of impact, many of the criticisms of socioenvironmental impacts target Brazil's environmental licensing and consultation processes as wholly inadequate and unjust from the standpoint of local communities. One book on the topic titled its concerns *Ways to Kill, to Die, and to Resist* (translated) (Zouri and Valencio 2014). Consultation with affected communities in particular commonly suffers from formalism and does not offer clear opportunities for them to actually block projects (Dias 2025). At the same time, Brazil's environmental impact assessment

process is comparatively strong for the Latin American region, especially in terms of the amount of technical information available to citizens with internet access (Hochstetler 2018). Congressional representatives have been trying, since 2004, to weaken and roll back the regulatory requirements and just succeeded in passing Legal Project 2159 in July, 2025. Lula has vetoed 63 of its provisions, including one that would have allowed medium sized projects to be self-certified and others that prevented full consultation and land demarcation of indigenous and other traditional lands. Minister of Environment Marina Silva, who claims that the draft bill would dismantle environmental licensing in Brazil, said the vetoes would allow Brazil to keep its commitments on deforestation and climate action (Câmara dos Deputados 2025). Even so, any potentially unjust outcomes of energy developments now become both more likely and more problematic.

Justice dimensions of oil and gas production and use

Beginning with the environmental implications of Brazil's oil and gas production, there is the obvious link to climate change, especially from the eventual consumption of those fuels. Because climate change is a global systemic phenomenon, the fact that Brazil hopes to export much of that fuel for consumption in other countries does not reduce its contribution to the larger problem. The impacts of climate change are already appearing both abroad and in Brazil, where there are evident links to both drought and forest decline in the Amazon region—with serious implications for Brazil's important agricultural industry—and recent flooding in the south of Brazil. Brazil's National Adaptation Plan identifies many of these impacts (Ministry of Environment 2016). The Brazilian government has argued that it can make its national share of contributions to global GHG mitigation through re-asserting control over deforestation and that it is unjust to ask it to also forego oil and gas production when wealthy historical producers are not (EPE 2024b). However, both fossil fuels and deforestation contribute to climate change and the many injustices associated with that. Petrobras itself has experimented with diversification into biofuels and wind power and has funded research into biofuels. Petrobras also joined 50 other oil producing companies at the COP28 climate conference to pledge to follow best practices for decarbonization in its activities (EPE 2024a:218). Even so, President Lula and leaders at Petrobras are insistent that Petrobras must continue to be profitable and pass on dividends and royalties and therefore production must continue (Couto and Góas 2025; Rosas 2024).

Beyond climate change, oil and gas production also carry more localized impacts that can be part of environmental injustice as local populations pay the price for national growth. Brazil's history of oil and gas production and refining has been largely off-shore and in the industrialized Southeast. Most contamination from oil spills and refinery operation has been in the waters along the large population centers of the Southeast region and generally threatens fisheries and tourism. Oil and gas producers in Brazil have avoided very large accidents, but a 2009 study found that Petrobras was responsible for 53 environmental accidents from 1997 to 2007, with especially serious spills in 2000 (Hochstetler 2011:366). A detailed study of 98 traditional communities

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Children in a canoe, Amazon. Image source. Photo by Neil Palmer/CIAT (CC BY-NC-ND 2.0).

in Rio de Janeiro and São Paulo states identified 22 socioenvironmental impacts that had been missed by the environmental licensing process of the pre-salt basins (OTSS 2024:82). Current plans by Petrobras and Brazil to expand off-shore production north into the Equatorial Margin would bring production closer to the Amazon, an even more ecologically sensitive area. The environmental agency IBAMA had refused to license exploration in an area about 500km from the mouth of the Amazon River, turning down two international companies in 2018 and Petrobras in 2023. In its view, large spills could not be fully avoided, contained, or cleaned up here, while the damages to the Amazon and peoples there would be extensive. A reef system is much closer and potential impacts are largely unstudied (Rodrígues 2023). Petrobras appealed the 2023 decision and its final outcome is not yet known, but the president of IBAMA over-ruled his technical staff in May, 2025, allowing licensing to move to penultimate stages (Martins and Antunes 2025).

From the consumption point of view, the burning of fossil fuels in vehicles and buildings add substantially to air pollution, especially in large cities and where heavy vehicles travel. It is a long-standing problem in Brazil's large cities, especially São Paulo, where industrial pollution was largely controlled in the 1980s, to be replaced by vehicular pollution in the 1990s (Hochstetler and Keck 2007). The human health impacts in the form of hospitalizations and premature deaths continue to be high, with associated economic costs (Santana et al. 2020).

Set against these risks and hazards of ongoing oil and gas production, any winding down of oil and gas production (not yet planned) would also need to address multiple justice implications. This is a major productive sector with a significant history of technical innovation under national control (Morais 2013). Requirements that Petrobras use locally produced inputs and labour have widened its economic impact. Petrobras directly employed 40,400 people in 2023, but the full sectoral employment is estimated at 616,000. In a country of some 230 million people this is not a large number, but it includes many well-paid jobs for highly skilled workers. World Bank estimates placed oil rents at

2.6 percent of GDP in 2021, but the share of government revenue is nearly triple that (Hochstetler and Lippolis 2024:6). Oil is one of Brazil's most valuable exports. These economic impacts are the foundation of the government's reluctance to stop oil and gas production and export. The distribution of compensatory revenues to producing municipalities also has created a large political base for sustained production, although development outcomes were worse in those locations than in municipalities without oil wealth (Lima-de-Oliveira and Alonso 2017).[4] The largest mobilizations around oil and gas production have been from oil workers challenging governance decisions around Petrobras and local communities demanding greater royalty shares (Hochstetler 2011). Any decision to move away from oil and gas would thus likely trigger justice-based dissent from these actors.

Justice dimensions of biofuels

While biofuels have been treated as an energy issue in Brazil, many of its most significant justice dimensions come from its agricultural side. Sugarcane cultivation, for example, was Brazil's first large-scale agriculture, built on highly concentrated land tenure systems. It was enabled by slavery of Black Africans in the Northeast of the country until 1888 and later by exploitative labour relations of other kinds like share-cropping and modern-day slavery. As Ian Carrillo notes, "Sugar-ethanol's system of commodity production is rife with environmentally hazardous labour at racially stratified work sites, where Black and Brown workers do entry-level tasks and Whites occupy managerial positions" (Carrillo 2021). The International Renewable Energy Agency (IRENA) shows huge labour demand in the renewable energy sector in Brazil with almost a million jobs in 2023 (IRENA 2024), but the majority of the jobs are for the large seasonal work forces needed to plant and harvest crops (although some of them are for the many refineries as well). Sugarcane laborers were poor even for agricultural workers, typically internal migrants known as "*boias frias*" or "cold lunches." Strikes in the 1980s improved conditions and wages only marginally (Rogers 2022:13). President Lula da Silva's first two terms in office (2003-2010) saw formalization of the rural labour force, which also benefitted from a rising minimum wage and new health and safety labour laws with stronger oversight (Carrillo 2021:47; Rogers 2022). Between 1990 and 2010, sugarcane acreage grew from 10.6 to 22.4 million acres, while workers became both more expensive and scarcer. Growers innovated in response by mechanizing the harvest, which also meant they no longer needed to burn the fields at harvest time, removing one of the worst workplace health hazards as well as air pollution and GHG emissions (Carrillo 2017:45-47). Mechanization that displaces workers is one source of injustice in the sector, although it is offset somewhat by the poor quality of the jobs—a different injustice—and the fact that overall employment in the biofuels sector continued to rise even as harvest jobs fell.

The overall impact of biofuels production on the environment is quite mixed. For climate change mitigation—not the historic preoccupation of biofuels policy, but now a primary policy framing of them—biofuels have had a beneficial impact on emissions from their use in transportation and other consumption. A recent study concluded, "The use of ethanol fuel allowed significant emissions savings for the transportation sector, causing

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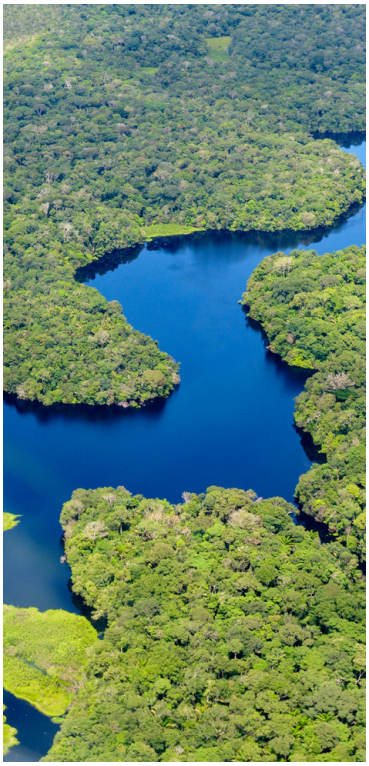
[4] More detailed information about royalty payments is at https://inforoyalties.ucam-campos.br.



Aerial view of the Amazon Rainforest. Photo by Neil Palmer/ CIAT (CC BY-NC-ND 2.0).

GHG emissions reductions of 39-46 percent compared with gasoline and a total avoided emission greater than 828 million metric tons of carbon dioxide equivalent" (Aguiar et al. 2025:248). Emissions from cultivation depend on many details of operations, including whether fossil fuel inputs are used (in fertilizers, machinery, and so on), how waste and agricultural residues are disposed, and, most critically, whether land is deforested for cultivation (Elbehri et al. 2013). For some time, agricultural expansion has been the single biggest driver of deforestation in Brazil and the planned further expansion of biofuels will require yet more deforestation or will displace food crops. This affects not just climate change and biodiversity, but also means rural communities lose their access to water and land and may be displaced. The high levels of water, soil, and air pollution diminish their quality of life even if they are not displaced (Schilling-Vacaflor et al. 2021). Brazil has always had very high rates of rural violence, centered on conflicts over land. The years 2023 and 2024 were the deadliest since the Rural Land Pastoral began keeping records, with 2250 and 2185 killed, respectively. Most are Indigenous or rural workers who are killed as they try to remain on their territories in the face of armed challenges for land control. Those responsible for the killings are "capital" in the form of established landowners or other actors trying to appropriate land for mining, energy, or agribusiness. Local police often support the killers or are themselves involved (Ojeda and Junqueira 2025). The broader picture is a classic separation of costs from benefits, the heart of environmental injustice issues: rural populations pay most of the costs of biofuel production, while the benefits accrue to urban populations that have cleaner air and to a global population which benefits from fewer GHG emissions.

Justice dimensions of hydropower

Hydropower electrified Brazil, so it can be credited for many of the benefits that electrification brings to households, industries, and a country. Comparatively cheap to build and operate where freshwater is available, it fueled a century of economic development there. Most of its labour demands and its other direct impacts come in the construction phase of a hydroelectric plant. If new hydropower is not being built, there are both fewer benefits (besides the electricity itself) and fewer new costs. Host municipalities do receive some annual compensation. Hydroelectric plants can vary a great deal in size, from just a few megawatts of installed capacity to the 14,000 MW of the Itaipú facility, the world's second-largest in installed capacity, built in the 1970s across the Brazil-Paraguay border. Impacts scale accordingly.

At the time of construction, which has taken nearly a decade for the very large plants like Itaipú and Belo Monte (built from 2011–2019 in the heart of the Amazon), large numbers of men converge on building sites for the project's jobs. While bringing clear economic benefits to the individuals and the location, the construction also brings, "displacement, rising costs of living, increased rates of violence, and a strained infrastructure," that worsen the lives of local residents (Klein 2022:19). The enduring impacts come from the plants themselves, especially those that involve building large reservoirs. The Itaipú reservoir flooded 1350 square kilometers, with the dam itself 8 km long (USGS n.d.). Forty thousand Brazilians were permanently displaced from their homes and land with the flooding, along with 20,000 Paraguayans (Blanc 2019). Even

residents who were able to remain in place lost many of their historic uses of the waterways, including for fishing, irrigation, transportation, and leisure.

There are equivalent impacts for animals and vegetation. Some of the military-era dams were built so hastily that they did not even fully clear the Amazonian timber first, leaving zombie forests that off-gassed methane at rates close to fossil fuel plants (Fearnside 2005). Hydropower is often considered to be free of GHG emissions, but studies of tropical hydropower plants show that they often have some emissions that vary by season and age (Barros et al. 2011). Had those forty identified future hydroelectric plants been built, the construction process as well as the reservoirs would have meant significant deforestation in the Amazon and for the very lengthy transmission lines needed, negating much of their climate benefit. The Belo Monte plant, originally conceived with a large reservoir that would have flooded some Indigenous lands along with parts of Altamira city, was eventually built with a lower-capacity run-of-the-river design that directed water through prepared channels. Ironically, some of its most significant impacts came from the drying out of the original river channel (Hochstetler 2011). While the reservoirs have clear negative impacts for climate change, they also have shown themselves to be highly susceptible to a changing climate, providing less and less-reliable electricity already in current climate and rainfall conditions.

Perhaps not surprisingly, these very large impacts have generated resistance, with recent opponents of hydropower and supportive academics using the language of injustice to argue against building any more hydroelectric dams (Bratman 2014; Just Transition Research Collaborative 2018:17-18). Even under the military government in the 1970s, farmers, landless peasants, and Guaraní Indigenous groups used land encampments and protests to try to block the Itaipú project (Blanc 2019). While they lost that battle, land-titled farmers did receive some compensation and activists later helped start some of Brazil's biggest and most visible social movements, including the Landless Workers' Movement - MST (*Movimento dos Trabalhadores Rurais Sem-Terra*) and the Movement of those Affected by Dams - MAB (*Movimento dos Antingidos por Barragens*) (Blanc 2019; McCormick 2009). The MAB eventually was able to support anti-dam mobilizations across the country, bringing technical, communications, legal, and other assistance to often isolated local communities (Hochstetler and Tranjan 2016). A constellation of non-state and state actors delayed construction of the Belo Monte dam for about eight years, bringing claims of rights to consultation and compensation to licensing processes, national and international public opinion, regional courts, and even the Inter-American Commission on Human Rights (Hochstetler 2011; Klein 2022).

Results of this resistance were often mixed, with projects almost always being built, even after democratic processes were restored in Brazil (Hochstetler and Tranjan 2016). Residents with clear land titles, often European in ethnicity, have fared better in receiving compensation than Indigenous and other forest peoples with collective or informal land rights (Blanc 2019). Collectively, the mobilizations for rights and against new hydroelectric plants do seem to have affected the overall fate of this historically important electricity source in Brazil. The mobilized opposition to hydropower has been mentioned in numerous planning documents as a limit on Brazil's electricity choices (Tolmasquim 2016:123-126). Little expansion is now planned.

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President Lula with Petrobras employees at the Propene Unit of the Replan Refinery in Paulínia. Photo by Ricardo Stuckert/PR (CC BY 3.0 BR).

Just Transition Issues—Current and Likely Future—of the Transition Itself

Governments, labour movements, and even some environmental activists in Brazil and elsewhere in the global South commonly frame climate change as a problem caused by the historical emissions from industrialization and economic growth that made the global North wealthy. To have been excluded from that growth while forced to provide the natural resource wealth that fueled it was bad enough; to be asked now to further fore-go growth to try to avoid further climate change which will be felt most strongly by vulnerable populations in the global South piles injustices on top of injustices. The win-win-win rhetoric of the green economy stings too, especially when the halo effect of green/clean obscures the fact that "the 'new' energy entrepreneurship often reproduces the same predatory and authoritarian mechanisms of the past" (Dias 2024:n.p.)[5] or justifies hasty decision-making. Beyond this broad critique, it is also necessary to look at the more specific experience of particular aspects of the transition within Brazil.

[5] Translation by author.

Wind power

From the standpoint of the Brazilian government and many in the industry, wind power has brought many economic benefits to Brazil that should be part of the consideration of its socioenvironmental impact, beyond its contribution to decarbonization. The wind sector was unusually successful in localizing a part of an energy supply chain and creating high-quality skilled manufacturing jobs through concerted industrial policy as implemented through BNDES (Hochstetler 2021: Chapter 3). Host communities show more employment and higher wages than non-host communities, especially for less-educated workers (Hernández-Cortés and Mathes 2025). As such, the industry has contributed to economic development in the Northeast region, long one of Brazil's poorest and too dry to host hydropower. This was the first kind of electricity generation in Brazil with significant private participation. Labour movements and their allies see the decline of public sector control as contributing to poorer labour conditions and future higher consumer prices, notwithstanding the efficiency arguments for privatization. They make similar critiques of the related opening to international actors, but Brazilian state and private actors were in fact seven of the ten largest owners of wind projects in 2018, thus retaining significant national control. Eletrobras (through its subsidiaries) itself had 11 percent of the market share, competing in the open auctions (Bayer 2018:2652). Any economic gains are under threat as the demand for wind power has died down. The wind power industry association, ABEEólica, is lobbying hard for novel solutions like the development of offshore wind (with a new domestic supply chain) that can help to decarbonize the offshore operations of Petrobras and other oil companies or green hydrogen that can use the excess supply of electricity to spur new product lines like green steel or green fertilizer.[6]

Many host community residents and civil society actors will not be sorry to see wind power go, however, if it does. In Brazil's Northeast, small cultivators, informal workers, and the former slave communities known as *quilombolas* share the unreliable rights to territory that are particularly threatened by new economic activities that require large amounts of land, as wind (and solar) power do. They also are often left out of meaningful consultation processes. While a wind power facility does not require the huge expanses of an Itaipú hydropower reservoir, its impact is more like those of small hydropower where the cumulative demands of many plants add up quickly. In 2018, Brazil already had 600 wind power farms located in 75 municipalities, mostly in the Northeastern coastal regions (Hochstetler 2021: Chapter 5). Residents have lost access to coastal areas and to the territorial bases of their communities, as well as losing traditional livelihood strategies like fishing, pasturage, and tourism, which may be criminalized (Brannstrom, Christian, *et al.* 2017; Dias 2025). These problems may extend to local ecosystems, especially for pre-2014 plants when environmental licensing was largely suspended for wind power plants on the understanding that they did not have negative environmental effects (Hochstetler 2021:178). A systematic review of the 600 wind power farms to 2018 found that community response did vary, with reported community resistance in just 25 percent of the 75 municipalities, although resistance has been growing as there is more experience with the wind farms and more collective regional response to them (Dias 2025; Hochstetler 2021:201-216; Plano Nordeste Potência 2024).

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[6] Interview with representation of ABEEólica, July 2024.

A unique feature of the grid-scale wind and solar installations is that they are typically placed on private land through agreements with landowners. While contributing to household income and possibly the higher employment and wages in host communities mentioned above, these benefits typically do not accrue to residents with informal and precarious land rights. In addition, even residents who have signed contracts are hampered by the individualized and confidential negotiations with firms that resulted in what they consider abusive contracts. Many have found themselves surprised to realize that they have made very long-term commitments that restrict their use of their own land, with fines for violations, so that they end up with a "silent expulsion" where they leave their land for the cities because they cannot productively use it. Payments that initially seemed generous may become less so (Dias 2025; INESC 2023). A broad coalition of civil society actors put improved contracts and environmental licensing at the heart of their proposals for new safeguards for wind and solar power (Nordeste Potência 2024).

Solar power

Grid-scale solar power has had less mobilized opposition in Brazil—none in the systematic study cited already for wind power—perhaps due to the fact that it can be installed in so many places in this sunny tropical country that there is less need to place it where there are competing uses. One community in Bahia has raised a legal case against Norwegian Statkrafts's Santa Eugênia Solar Complex for unnecessary deforestation for a solar farm, done without prior consultation or impact studies and fully avoidable (Dias 2025). There have been similar concerns about land-use contracts as just described, for solar power.

Distributed solar power, where individuals or firms decide themselves to install solar panels, usually on their own property, avoids the dilemmas of siting altogether, a rare exception to the contentiousness around siting energy installations in Brazil.

The justice issues around solar power have more to do with where solar power fits in the broader political economy of electricity. In some countries, solar power serves an important access function in supplying electricity to populations that are remote or where it can provide initial access cheaply before larger electricity systems can be built out. Brazil has limited ability to use solar power in this way, since access to the national electricity grid has been nearly universal since 2000.[7] Where it is not, as in remote areas of the Amazon, solar power is a complicated replacement for diesel and gas systems already in use (IEMA 2018:419). A 2023 Amazonian Energies Programme hopes to advance energy substitution there, alongside the existing Light for All programme (EPE 2024a:419). In the meantime, distributed solar power in Brazil has mostly been installed by comparatively wealthy urban consumers who already have electricity access and the terms under which most of them installed it explicitly exempt them from paying the costs of the broader network. This is introducing a classic version of the "utility death spiral" where the broader network struggles to maintain the collective service, now with disproportionate numbers of poorer consumers who cannot afford the up-front costs of their own solar installations (Castaneda, et al. 2017). For Rodrigo Sauaia, CEO of the solar industry association ABSolar, this is a temporary stage before everyone can afford the now-cheaper distributive options and the system as a whole moves to distributive generation, but

[7] Currently just 0.2 percent of Brazilian residences lack access to electricity, or 500,000 households; 228,000 of these are in remote areas of the Amazon (Empresa de Pesquisa Energética 2024a:493).

that transition has not happened even in wealthier societies and some rocky and expensive stages of transition seem likely.[8]

ABSolar is similarly sanguine about the fact that the solar industry in Brazil has managed very little of the localization and industrial innovation of most other parts of the energy ecosystem there. Most solar panels are imported and installed by a growing installation army, with little diversity to their economic activity. He echoes the critiques others have made of industrial policy: it provides benefits to a narrow slice of economic actors while raising costs for many more. It has been a decade (since 2014) since anything else was tried (Hochstetler 2021:104). For both wind and solar power (of all kinds), there are also justice dimensions of their supply chains, and specifically of their need for comparatively large quantities of critical minerals (IEA 2021; Mulvaney 2019).

Critical minerals

Development benefits from mining are mixed, with benefits rising if minerals are processed and used in domestic manufacturing. As mentioned above, it is far from clear now that this will happen, with equally unclear implications for the labour force. Bolsonaro's Decree 11,120 of 2022 opened up mining to foreign participation and Lula has left that regulation in place, further limiting the odds. Communities where mining takes place receive a Financial Compensation for Exploitation of Mineral Resources (CFEM). Historically, it was meant to have a reparatory function, compensating for social and environmental damages caused by mining. Two decrees during the Bolsonaro years (10.657/2021 and 10965/2022) have removed that expectation so the CFEM can now be spent for any infrastructural purpose. Activists worry that this will give local governments an additional incentive to encourage mining without taking socioenvironmental considerations seriously (Dias 2025). Even beforehand, there was very little transparency in the municipalities that received the highest transfers—which were between 30 and 75 percent of total municipal revenues (Giusti et al. 2023:101352).

Critical minerals have obvious and positive importance for their decarbonizing role in the supply chain of renewable energy, EVs, and more. Other environmental impacts are more worrisome. Officials in both the Bolsonaro and Lula administrations have stressed the need to speed up environmental approvals of mining for critical minerals, while promising that they will respect socioenvironmental limits (Moura and Sousa 2024; Zaparolli 2025). Yet mining routinely involves deforestation and the destruction of natural eco-systems, as well as degrading waterways. Brazilians also remember catastrophic disasters, like when retaining ponds collapsed in Brumadinho, Minas Gerais, in 2019, killing local residents and causing widespread socioenvironmental damage. Reparations were still unpaid five years later (Conectas 2024). The Mining Observatory has argued that environmental impact assessment has been slow to recognize the impact of already-existing climate change on mining, namely that both floods and drought bring new risks of disastrous environmental and community impacts from mining activities (Observatório da Mineração 2025).

Conflict with local communities is already common around extraction of energy transition minerals. There were 348 occurrences of conflict between 2020 and 2023, affecting

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[8] Interview with Rodrigo Sauaia, CEO of ABSolar, July 2024.

Brazilian National Indigenous Mobilization, 2018. Photo by 350.org (CC BY-NC-SA 2.0)

more than 100,000 people, in 34 Indigenous communities, 30 *quilombola* communities, and 27 with *ribeirinhos* (river people), among others—249 locations in all (Mansur et al. 2024). There are particular conflicts around lithium in the Vale do Jequitinhonha in Minas Gerais (Southeast), where the desire to start up production quickly has led communities to object that decisions were taken without their consent and without adequate studies of social, environmental, and cultural impacts (Mansur et al. 2024:37; Dias 2025). The centuries-long history of mining there has delayed recognition and demarcation of Indigenous and *quilombola* communities' territorial claims, allowing mining licenses to be granted without that restriction. Water access and quality is another sore point (Krenak 2023). Researchers in the state have formally argued that the environmental licenses for Sigma's huge lithium project in the state should be cancelled and production stopped, due to problems in the process and technical problems with the impact analysis, as well as Sigma's use of outdated and unnecessarily damaging technologies (Laschefski 2025).

Emerging sectors

The justice-related impacts of emerging decarbonized sectors like green hydrogen and EVs are hard to judge, precisely because they are still quite incipient. Given their reliance on renewable energy, they do effectively take on the existing justice impacts of renewable forms of energy as described above, with green hydrogen leaning particularly on further development of wind and solar power and the use of EVs reliant on the whole electricity matrix as well as biofuels for hybrid models. Both also therefore imply continued production and consumption of critical minerals. Those impacts will not be further discussed here, but it should be noted that the energy demands of green hydrogen are particularly large: seven

(now eight) of the announced projects in Ceará alone need electrolyzers with a GW of installed capacity (Cunha 2024:13). Any associated manufacturing that is also developed also requires energy of various kinds.

Conversely, the development of these new green sectors generally implies less consumption of fossil fuels, so reduces those impacts. This effect is reduced in turn by the Brazilian presentation of natural gas as a climate-friendly fuel, as in its Gas for Employment initiative (MME 2023). While low in carbon, gas produces serious short-term GHG effects. This allows some products to be presented as "green," including potentially "green hydrogen," while continuing to contribute to climate change.

Looking at the proposed new sectors, what do they offer in terms of development benefits that might be seen to balance other injustices and costs? For green hydrogen, Cearense academic Clayton Cunha describes a choice between a Saudi Arabia model where huge quantities of fuel are exported with little further development versus a São Paulo model where reindustrialization takes place, through import-substitution at first (Cunha 2024). Brazil currently exports much of its ore and imports much of its steel, so would need to expand and rework its steel production to take full advantage of its green hydrogen potential (Guerra et al. 2025:19-21). It also imports 70 percent of its fertilizer (Cunha 2024:17). At least for now, the Port Complex is focusing on export of fuels, the "Saudi Arabia" model. Plans to develop a supply chain for green hydrogen, like the electrolyzers, are not evident, nor are discussions of how to minimize the socioenvironmental impacts of the large amounts of electricity needed (Cunha 2024:18-20; Pecém Industrial and Port Complex 2021). The industry association for green hydrogen predicts 40,000 new jobs in not just steel and fertilizer, but also e-fuels and e-methane (ABIHV 2025). Any large jobs promise depends on further industrialization, however, as the production of green hydrogen itself is capital-intensive with few jobs after construction.

Development in the EV industry has helped to revive an automobile manufacturing sector that had been in sharp decline. This means new manufacturing jobs, highly valued in the Brazilian context. An all-Brazilian consortium led by Eletra (e-equipment) has successfully built e-buses for São Paulo city and other locations (Buch 2024). However, all current participants in manufacturing electric automobiles are MNCs, so some analysts conclude that they will be doing their R&D elsewhere (Guerra et al. 2025:11-13). The strong presence of Chinese firms leaves the question somewhat open, as little has been seen of their practices in this sector so far. The just-opened GWM facility claims to have integrated Brazilian R&D and hydrogen technology and is aiming for 60 percent local content by 2026, reflecting a broader strategy of emphasizing localized innovation (Carter 2025). Brazil also has a budding battery production cluster, including some with foreign, including Chinese, or joint investment that will face fierce global competition. Upstream mining and value-added processing, both possible in Brazil but with significant socioenvironmental challenges as discussed above, would be key to developing this industry further (Guerra et al. 2025:34). As already highlighted, one compensation is that EVs—whoever manufactures them—can reduce the historically high air pollution in Brazil's large cities and the associated health impacts there.

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Conclusion

Hands of an agricultural worker in Brazil. Photo by Carlos Decourt (public domain).

As this survey shows, energy transition is still incipient in Brazil, especially if transition means actually reducing oil and gas production. In addition, and unfortunately, there is no form of energy in Brazil that is free from negative socioenvironmental and developmental impacts that might present an energy injustice. However, different kinds of energy present different constellations of impacts on different people, including different vulnerable groups of people. Thus, thinking about a just energy transition requires thinking of this bundle of impacts, of both new sources of energy and existing ones. This conclusion is not to propose a giant final solution, but to spotlight some of the patterns of impacts and the difficult tradeoffs they pose for a just energy transition.

The strong regional differentiation inside Brazil has clear spillovers into thinking about the impacts of energy production and any changes in what is produced. In the North/Amazon, there are important potential impacts from any new hydropower, as well as activities of all kinds that drive deforestation, including mining. Wind power and grid-scale solar will, in contrast, most affect the Northeast, as will green hydrogen production and some biofuels cultivation, giving that region a diverse set of impacts. Oil spills have been along the Atlantic coast of the Southeast, but may now approach the North and Northeast. The effects of biofuels cultivation are widely dispersed (Northeast, Southeast, and Centerwest) as is mining, although so far critical minerals are mostly in Minas Gerais in the Southeast. These

regional impacts are overlaid with the uneven presence of Indigenous and other traditional peoples (rural groups historically tied to their territories). Indigenous populations are mostly in the interior of the country, in the North, Southeast, and South, while two-thirds of *quilombola* communities are in the Northeast, often coastal, and a third in the North. Other traditional peoples like *ribeirinhos* (river dwellers) and rubber tappers—non-Indigenous but with a century or more of traditional livelihood strategies based on natural resources—are mostly in the North. Choices among different kinds of energy are in essence choices to impact some groups of people rather than others. The alternatives associated with a decarbonizing energy transition so far have brought especially heavy impacts on communities in the Northeast and Southeast, while the decline of new hydropower has brought some relief to the diverse traditional communities of the Amazon, who may now experience the impacts of ongoing oil and gas production.

Cutting into the patterns another way shows that the 12 percent of Brazilians who are rural residents experience more directly the impacts of mining, deforestation for hydropower, and the rural pollution that comes with cultivation of biofuels, as well as hosting more than their share of electricity installations in general. Across Brazil's vast rural areas, such communities experience land precarity, loss of livelihood strategies, and the loss of biodiversity they depend on. This disproportionate rural burden from a national electricity grid and any national wealth resulting from energy production for development is an injustice. Rural communities must be consulted about new initiatives, and there needs to be a robust process of identifying, avoiding - where possible, and compensating for those impacts. At the same time, the energy needs of the urban 88 percent of the population cannot be ignored. Producing no new energy is not a real option, even if some efficiency gains are possible. Urban populations also especially suffer from ongoing dependence on fossil fuels, in air pollution and its health impacts and oil spills for those along the coast. All Brazilians face (different) impacts from climate change.

Other dimensions of energy justice relate to the clear desire on the part of Brazilians—across time, party, and regime—to use energy policy for development, linking energy choices to job quality and quantity, both *status quo* and future. But many Brazilians also clearly see climate change as important and are concerned about other socioenvironmental impacts of energy choices. In some cases, benefits and costs fall in the same place, as when place-specific economic benefits from developing wind power and related industries like green hydrogen will accrue to the Northeast, which also hosts the place-specific socioenvironmental costs of siting of the wind projects. Of course, this does not mean that individuals will have a balance of benefits and costs, nor even communities. In other cases, there is the wider separation already discussed, geographically and socially, between those who benefit and those who pay the costs of energy choices. With respect to these two aims, it is worth noting that distributed solar power has the fewest identified socio-environmental costs, while also offering the fewest development benefits. Conversely, wind power offers a strong promise of decarbonization and further development and has limited environmental impact compared to options like hydropower, but has also developed unmissable social rejection in the Brazilian Northeast.

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While it may appear that development and environmental concerns face difficult tradeoffs in the energy sector in Brazil, choices outside the sector also affect both development strategies and climate action and a just unfolding of them. For example, deforestation and land use change have long been the major sources of Brazil's GHG emissions and while some of those emissions are related to the energy sector, many have little to do with it. Similarly, many development choices—like the quality and form of education and other training, to list just one—are in other domains and may counter or reinforce those in the energy sector. The same is true for the justice dilemmas that arise. The most severe injustices come where injustices in the energy sector line up with injustices in other domains, but underlying causes like racism or historical land distributions are not readily resolveable through the energy sector itself. They require other, more directed, approaches. Elaboration of this point is beyond the focus of the brief, but it is helpful to remember that energy is not a closed system.

Finally, this discussion has mostly focused on Brazil itself, but both a global climate solution and Brazil's own development prospects are strongly influenced by developments outside the country. This is true even for this big and influential country and will be even more relevant for other countries in the global South. Global geopolitics and geoeconomics make the current time especially inauspicious for both climate solutions and development. This is also an injustice. To give just one example, there is a geopolitical struggle currently over control of critical minerals, and a great deal of international pressure to export large quantities of raw minerals. Without that demand, Brazil might have the latitude to extract less, and to reduce the impacts of extraction, while better controlling the process and gaining more of the value-added of the production (Moreira 2024). Still, inside that pressure, Brazil retains considerable scope for action to achieve its climate and development aims in a way that is more just rather than less so. And in international initiatives like the COP30 climate conference in Belem, Brazil can take steps that start to rejuvenate an ailing climate multilateralism that pushes back at the pressures that are deepening inequality and injustice both globally and within countries.

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JUST ENERGY TRANSITION IN BRAZIL

This report reflects on Brazil's national characteristics and energy history in order to address three questions: The first question discusses multiple kinds of energy in Brazil with the aim of identifying how much and what kind of energy transition is actually happening. As in many countries, energy transition in Brazil is uneven and partial, with oil and gas production continuing to grow alongside new low-carbon energy sources. The second question focuses on the justice issues that arose with the historical status quo of Brazil's energy sector before turning to the third question of the justice dimensions of the transition itself. Unfortunately, there is no form of energy in Brazil that is free from negative socioenvironmental and developmental impacts that might present an energy injustice. However, different kinds of energy present different constellations of impacts on different people and groups. Thus, thinking about a just energy transition requires thinking of this bundle of impacts, of both new sources of energy and existing ones. Despite challenges, Brazil retains considerable scope for action to achieve its climate and development aims in a way that is more just rather than less so.

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