

Chinese investment in the Northeast region of Brazil: an analysis about the renewable energy sector

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Abstract

Purpose – This paper seeks to analyze the relationship between China and the Northeast region of Brazil, aiming to identify how the renewable energy sector is being developed.

Design/methodology/approach – The authors analyzed secondary data from the official databases from China-Brazil chambers of commerce to establish the main points related to renewable energy in Brazil's Northeast.

Findings – It is possible to notice the main investments, highlighting the wind energy as a more prominent source recently. The authors also point the huge influence from China on Brazil's Northeast energy sector.

Research limitations/implications – It is difficult to identify the amount of Chinese capital due to the large number of mergers and acquisitions that has been taking place in recent years.

Practical implications – Identification of regions that have been receiving investments and the main interests of Chinese investors in the renewable energy sector.

Social implications – Demonstration of how the renewable energy sector has taken an important turn in Brazil due to Chinese investment.

Originality/value – To evaluate a regional consortium, analyzing its strategies for partnerships with China to help each other in global questions, as is the case of renewable energy.

Keywords Brazil-China relationship, South-south cooperation, Renewable energy, Northeast consortium

Paper type Research paper

1. Introduction

Brazil has been trying to develop its economy over the last decade, however achieving results below expectations for emerging countries. Meanwhile, the political relationship between the federal and state governments has indicated serious divergences about how to conduct the economy in the region, which resulted in the organization of state governments as regional consortiums.

The institutional design that emerged from the Federal Constitution of 1988 led the states to deal with difficulties and with the need to adapt their governance capacities, whether

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economic-fiscal or political-institutional. Since then, issues such as regional disparities and inequalities have entered the agenda of public debate (Arretche, 2004; Vergolino, 2013). Furtado (1992) had already indicated economic and social differences among Brazilian regions, noting that less developed regions (i.e. Northeast) need stronger economic planning.

In this scenario, the Northeast Consortium was created to bring together all nine governors of the region, which has currently a population of over 56 million and a gross domestic product of 183 million dollars. This consortium has sought to create partnerships with other countries (i.e. China) to promote economic development and to help one other in global issues. One of these issues is the use of renewable energy, which addresses international agreements on the environment without threatening the region's energy security (Clementino, 2019).

It is worth highlighting China as one of the main trading partners with Brazil, especially the Northeast region. Although there is a strong influence of the agricultural sector in this relationship, other types of investments and partnerships have been developed, such as those related to renewable energy (Gélvez Rubio & Gachúz Maya, 2020).

In addition to the importance of the theme in global climate agreements, renewable energies have gained special prominence more recently because of the COVID-19 pandemic. In a comparison between the beginning of 2019 and 2020, renewable energies were the only source that did not have its demand suppressed, while there was a significant drop in oil, coal, and natural gas (IEA, 2020a, b).

Thereby, this paper seeks to analyze the relationship between China and Northeast Brazil, aiming to identify how the renewable energy sector is being developed.

In this sense, in addition to this introduction, the article is divided into other sections: (1) the context of Sino-Brazilian cooperation based on China's international action strategies; (2) an overview of the energy sector as strategic area of regional development in the Sino-Brazilian relationship; (3) methodology; (4) analysis and discussion of results; and (5) final considerations.

2. International development cooperation between China and Brazil

Before analyzing the Chinese presence in the Brazilian energy sector, especially in the Northeast region, it is important to understand how China has been making investments around the world within the One Belt One Road strategy.

Fueled by market-oriented reforms and capital accumulation since 1979, China has experienced unprecedented economic growth. The past decades have witnessed a substantive influx of foreign direct investment (FDI) in China, contributing to the country's domestic economic growth. Despite the uncertain global political and economic environment, China's outbound direct investment (ODI) has been booming and overtook FDI in 2015 (Huang & Xia, 2018). With its increasing capacity, China has gradually shifted its roles from an international aid recipient to a donor in areas of overseas investment and technology transfer.

China has considered itself as a firm advocate of South-South Cooperation (SSC), an antithesis of the North-South Cooperation, allowing that developing countries work together to find solutions to common development challenges. China's engagement in South-South cooperation grew out of the Bandung Conference in 1955; later, the country expanded its policy from Asia to the African continent. However, in the 1970s and 1980s, the Cold War, oil crisis, debt crisis, and the follow-up de-industrialization, particularly in Africa and Latin America, led to a temporary collapse of South-south Cooperation (Kragelund, 2019).

With the globalization, the development of new emerging economies, i.e. BRICS (Brazil, Russia, India, China and South Africa) has rebalanced the global governance and come to strengthen South-South Cooperation since the mid-2000s. Arguably, one of the most

ambitious strategies in international development is the Belt and Road Initiative (BRI), which was launched by China in 2013 and involved infrastructure development and investments in nearly 70 countries and international organizations, covering 65% of the world's population and 40% of the global gross domestic product as of 2017. The initial plan of the BRI by the Chinese government was to enhance regional connectivity and create a unified large market. The initiative is believed to have extended China's global influence; however, it also creates unsustainable debt burdens to China since eight BRI countries are vulnerable to debt crises as that of 2018 (Chatzky & McBride, 2020).

China's ambition in promoting international development is perceived through its tangible involvement in the increase of the outbound direct investment (ODI) in developing countries, especially in Africa. In August 2017, China's National Development and Reform Commission (NDRC) has formalized the ODI transaction regulation to classify outbound investment into three groups: encouraged, restricted, and prohibited transactions. The share of investment to BRI countries has increased to 12% of total ODI in 2017, in contrast to only 8% in 2016, covering 65 countries (Huang & Xia, 2018).

Even though China's "going out" policy has gained prominence over the last decade with its myriad development projects under the banner of the Belt and Road Initiative, its economic ties to South America have become crucial for both regions. In March 2020, 19 countries in Latin America and the Caribbean (LAC) have joined the Belt and Road Initiative by signing policy cooperation partnerships with China.

To illustrate the sheer scale of these economic ties, an analysis conducted by Boston University's Global Development Center estimates that imports from China were equivalent to 3.1% of the GDP in Latin America and the Caribbean (LAC) (Ray & Barbosa, 2020). Moreover, China has been the region's largest single source of sovereign finance in five out of the last ten years. According to a 2019 brief by the Atlantic Council, "Bilateral trade grew twenty-five times, from \$12 billion in 1999 to \$306 billion in 2018, placing China as Latin America's second-largest trade partner, after the United States" (Zhang, 2019).

Since 1993, leaders from China and Brazil have started to discuss the possibility of strategic partnerships. Both countries share the identity of major developing states and realize the importance of developing longstanding, stable, and strategic bilateral relationships (Niu, 2010). In 2009, China surpassed the US and the EU, becoming Brazil's largest trade partner and has remained in this position since then. Likewise, Brazil has been on China's Top 10 partner list for years (7th in 2018) and is one of the key destinations of Chinese foreign direct investment (FDI). Although Brazil is not a member country covered by the BRI, it is a signatory state of the Asian Infrastructure Investment Bank and regarded as a prospective BRI member.

In addition to the fast-growing commercial ties that have marked the China-Brazil partnership, China has also played a substantial role in supplying loans and investment to Brazil for over a decade. China's two main policy banks, China Development Bank (CDB) and the Export-Import Bank of China, have provided over \$28 billion in loans to Brazil since 2007, making it the second largest borrower in Latin America. Remarkably, roughly 90% of this sum was directed at the energy sector (Gallagher & Myers, 2020).

Regarding the energy sector, China is currently one of the world leaders in both the production and installation of renewable energy technologies. The renewable energy's shares in generation and consumption have been growing over the years. In 2017, renewable energy comprised 36.6% of China's total installed electric power capacity, and 26.4% of total power generation (Dong & Qi, 2018). According to China's 13th Five Year Plan, 31% of total electric power generation was planned to be from non-fossil energy sources by 2020 (State Council, 2016). This has been a significant achievement since the colossal energy demand in China has been historically dominated by fossil fuels. The upgrade of China's renewable energy technologies provides an opportunity for many developing countries to learn from this

experience and transfer appropriate catch-up technologies, which can be used to help these countries to overcome regulatory, technical, institutional and financial barriers.

According to Li, Gallagher & Mauzerall (2020), in addition to foreign direct investment, other forms of cross-border activities have fueled the development of the power sector beyond China, including development finance from Chinese national development banks, import of power equipment from China, and foreign utilization of engineering, procurement, and construction (EPC) services from China. Between 2000 and 2017, Chinese firms invested approximately \$115 billion in 462 overseas power plants, with a total generation capacity of 81 GW. Among the 81 GW of capacity, the net capacity owned by Chinese companies is 59 GW (Li, Gallagher & Mauzerall, 2020).

Despite maintaining its global leadership in investments, manufacturing, and deployment of solar and wind energy since 2008, its two policy banks are charged with promoting the global expansion of the Chinese renewable industry under the international development strategy. Only 2.6% of the Chinese international financing in the energy sector has been destined to renewable energies. Of this percentage, between the years 2010 and 2018, 12.1% were directed to Latin American countries (Kong & Gallagher, 2020).

Regarding the regulation of the energy sector, there is no single agency in China in full charge of the overall renewable energy policy development and implementation. The National Development and Reform Commission (NDRC), the National Energy Commission (NEC), and the Ministry of Finance (MOF) are key governmental agencies under the State Council that influence renewable energy policy making, implementation and supervision. The NDRC is responsible for drafting the overall national economic development plan; the NEC oversees planning and monitoring of specific energy sources; whereas the MOF formulates and monitors financial strategies and plans under the direct leadership of the State Council. As for international development cooperation, the China International Development Cooperation Agency (CIDCA) was established in March 2018 to replace the Ministry of Commerce as the lead coordinating body of Chinese foreign aid.

The promising South-South Cooperation (SSC) and the ambitious Belt and Road Initiative (BRI) have demonstrated that China's involvement in Brazil's renewable energy market will be towards a broader and more strategic engagement, and the case illustrated in this study is an attempt to stress cooperation and partnership ties and brings bilateral governmental agencies, businesses, communities, and public and private stakeholders together. However, it is important to highlight that in 2019 and 2020 there were diplomatic conflicts between the Brazilian federal government and China. This meant that some strategic issues had to be handled directly between the Brazilian state governments and China, in order not to harm regional interests.

In the case of renewable energy, the Northeast displays a privileged geographic position for its use. Thus, the governors of the Northeast region have been directly seeking partnerships with China and other countries to explore this potential.

3. Renewable energy scenario in Brazil

The electricity sector is key for Brazil's growth, since, as the economy grows, the energy supply must also increase to sustain the increasing demand that accompanies the GDP. Therefore, energy security is a priority factor in the country's national development strategy.

Data from the Brazilian State Agency of Energy (ANEEL) shows that 82.75% of the Brazilian electric matrix comes from renewable sources of energy. Among renewables, energy from hydro sources accounts for the largest share (63.2%), followed by wind source (9.1%), biomass (8.8%) and solar (1.7%).

Besides, Northeast Brazil is the region with the greatest potential for wind power generation in the country with 91.5% of installed capacity, equivalent to 25.6 GW, and energy

from photovoltaic panels with 56% of generation in the country, or 7.53 GW (ANEEL, 2020). Among the five largest wind power generating states, four are in the Northeast: Rio Grande do Norte, Ceará, Bahia and Piauí. Moreover, among the five largest solar energy producers, three are to be found also in the Northeast: Bahia, Piauí and Ceará (ANEEL, 2020).

When looking at the timeline, the development of solar and wind power generation is still recent in Brazil. While hydroelectric and biomass technologies have evolved since the end of the 20th century, wind and solar energy have just started their growth paths (Cavalcante, 2018). The milestone to this occurred in 2002, with the launch of a program to encourage renewable energy sources by the federal government. This grew in 2009, when auctions for the creation of plants and the contracting of this type of energy started to take place.

Still, the economic recession of 2016 reduced electricity demand on a scale that had not been seen since 2009 (Cavalcante, 2018). Thus, auctions were suspended and only resumed in 2017. The last major auction of wind and solar energy took place in October 2019. At the time, 43 projects for the generation of wind energy were contracted, all in the Northeast region, totaling a potential for generation of another 1.04 GW and investments of approximately US\$870 million. In solar generation, 11 projects were contracted for US\$405 million to generate 530 MW in the states of Rio Grande do Norte, Piauí, and Ceará (ANEEL, 2019).

Associated with the rapid development of renewable energy technologies in the global market, Brazil's integration process in this market has been widely affected. The financial viability and the expansion of these technologies were factors that facilitated the development of this market in Brazil. According to Cavalcante (2018), the Brazilian renewable sector fits the demands of the global renewable energy market due to the underdeveloped national sector and the need to import most of the technology.

About the companies focused on renewable energies, in 2017 it was announced that the CPFL Energia, the largest private group in the Brazilian electricity sector, became controlled by the Chinese State Grid, which acquired 54.64% of its shareholding. In addition, the Chinese State Grid invested approximately US\$5.8 billion in Brazil in 2018 through eight projects. One of them was to strengthen the Iracema Transmissora de Energia in the Curral Novo do Piauí substation, with an investment of BRL 13 million (CEBC, 2019).

Besides State Grid, the renewable energy market in Brazil is shared by some of the main foreign companies pertaining to the clean energy sector in the world. Among them, the Italian Enel™, the Spanish Solatio and Elecnor™, the EDP Renováveis™, the Sino-Canadian Canadian Solar™, the Chinese SPIC™, CGN™, CTG™, the Brazilian Casa dos Ventos™ and Omega Geração™, and even the British oil company BP™ (Costa, 2020).

In this scenario, the Brazil has been benefited from rising shares of Foreign Direct Investments in recent years. In the photovoltaic solar sector alone more than 130 thousand jobs were created from 2012 to 2019. About 85% of power investments in 2018 were financed on the balance sheets of utilities, independent power producers, and consumers (for distributed generation) (IEA, 2020a, b). In this way, there was a growth of 384% in 2019, when 640 MW were contracted in business (Costa, 2020).

Although some factories related to renewable energies have been launched in Brazil in recent years, most of the photovoltaic panels are imported from companies such as the Chinese Jinko™, BYD™, JA Solar™, Trina™ and Canadian Solar™, revealing the importance of China in the value chain (Portal Solar, 2019a).

Thus, the potential of renewable energies in Brazil stands out, as well as the predominance of the Northeast region due to its privileged geographic position for both wind and solar energy.

4. Methodology

This study is exploratory and descriptive, and aims to survey secondary data from government databases and chambers of commerce. To conduct the analysis of the

investments of Chinese companies in Brazil – including mergers and acquisitions (M&A), greenfield investment and construction contracts – this study relies mainly on the Brazil-China Business Council (abbreviated as the CEBC in Portuguese) and China Global Investment Tracker (CGIT), both providing compiled data at the national level.

The CEBC is the official bilateral organization for the promotion of business partnership between the two countries conforming to the 2015 China-Brazil policy document (*Plano de Ação*). As a liaison to Chinese businesses in Brazil, it has access to privileged data on Chinese investments in the country.

The China Global Investment Tracker includes a comprehensive record of Chinese investment and construction contracts in Brazil between 2005 and 2019. The cumulative sum of this activity amounts to over US\$68 billion (Scissors, 2020).

The data referring to the installed capacity of electric power generation in Brazil, the generation data by state, the plants and the generation agents that make up the Brazilian electric sector, as well as the location of the projects spread across the country come from the Information Databank of the National Electric Energy Agency (ANEEL). The data on winners of auctions and concessions for power generation from renewable sources also come from ANEEL reports.

It is important to note that this research encountered a few limitations in accessing and updating data covering all investments and acquisitions of renewable energy generation projects by Chinese companies. However, this fact does not limit the potential for reflection and analysis of this research. Given the scarcity of published studies on the topic, this is an important contribution to the debate on renewable energy.

5. Data and discussion

According to CEBC, for any given year between 2014 and 2018, the energy sector ranked first in terms of investment compared to many other sectors, including agriculture and oil extraction (CEBC, 2016, 2017, 2018, 2019). Indeed, in 2018, investments in electricity generation, transmission and distribution projects comprised most Chinese investment projects in Brazil (CEBC, 2019). These capitals are not only private, but mainly from Chinese state-owned companies that are acquiring participation in new projects and enterprises in the sector (creation of joint ventures, for example) or in the existing infrastructure.

The past decade was marked by several developments in the sector. Let us now analyze how China gained space in the Brazilian market in just over ten years, mainly in the generation and transmission sectors of electric energy – especially wind and solar.

5.1 Chinese investments in the Brazilian energy sector

A considerable part of Chinese investments in the Brazilian energy sector is concentrated in fossil fuels (oil and gas), hydro power, and the energy transmission sector. Companies such as Sinopec, State Grid, Sinochem, CNOOC and CNPC have been increasingly approaching the Brazilian market. After the discovery of offshore oil reserves in the Campos Basin (Rio de Janeiro) between 2007 and 2009, the so-called Pre-Salt Layer, Chinese investments increased rapidly in the Brazilian energy sector. They outperformed investments from other strategic countries, such as Russia, Indonesia and India, which before 2009 were leading the flow of investments (Cavalcante, 2018). Between 1990 and 2015, 13 international energy acts and agreements were signed between Brazil and China, among which a considerable part involves renewable sources (Montenegro, Paiva & Feitosa, 2020).

Shoujun and Miranda (2016) distinguish Sino-Brazilian energy cooperation at two parallel but complementary hierarchical levels: the government-to-government level and the business-to-business level. From the first perspective, since the beginning of this century,

the two countries have developed a high-level dynamic that involves bilateral and multilateral agreements focused on deepening oil trade, financing and developing oil exploration and production, energy equipment, peaceful use of nuclear power, bio fuels, and new energy sources. This government-to-government cooperation has generated incentives for cooperation at the business-to-business level, in which the potential development of Brazilian natural resources makes Chinese companies to exploit the commercial opportunities arising therefrom, with emphasis on the crude oil trade, market access, technological absorption, and bio energetic cooperation (Shoujun & Miranda, 2016).

Through strategic associations, China aspires to gain access to knowledge and technologies in the area of oil production and exploration in deep waters, which would allow it to operate commercially in the exploitation of oil in the South China Sea region. In this sense, the Sino-Brazilian relationship in the oil sector is also based on access to the Chinese market and economic resources in exchange for Brazilian know-how in offshore oil exploration (Shoujun & Miranda, 2016).

In 2009, the China Development Bank made the largest financial contribution to date with a US\$10 billion loan to Petrobras to guarantee part of its oil exports to China. This first movement was followed by a series of investments. In the transmission sector, the highlight is the acquisition by the Chinese State Grid, in 2010, of seven electric transmission companies in an investment of US\$1.7 billion, and, later, the subsidiary State Grid Brazil (Cavalcante, 2018; Oliveira, 2016). Sinochen acquired 40% of the Peregrino oil reservoir in the Campos Basin. More recently, CNPC and CNOOC took strong positions in offshore oil exploration in the last auction that took place in November 2019. On that occasion, each acquired a 10% stake in consortia organized for the development of Campo de Libra, according to ANEEL.

In the first semester of 2020, due to the circumstances triggered by the COVID-19, the world's energy sector has suffered its effects. This scenario in Brazil was also noticed through the decrease of energy demand and supplies. Therefore, the Chinese economic support has reduced as well. According to the Electric Energy Trading Chamber (CCEE), the reduction in energy consumption by industries has already fallen 18% since the beginning of the country's lockdowns.

Nonetheless, it is possible to notice, in the pandemic context, that renewables were the only source that posted a growth in demand driven by larger installed capacity and priority dispatch (IEA – Global Energy Review, 2020a, b) – as shown in Table 1. It demonstrates future effects on this sort of market, which becomes increasingly prominent in the global energy matrix.

5.2 The renewable energy market in evidence

With regard to renewable energy, which is the object of analysis in this article, the solar and wind energy markets are recent in Brazil and are still expanding, in view of the great potential to be explored, especially in the Northeast.

The numbers show that 85% of national energy production from wind power comes from northeastern states (Abeolica, 2020), and 65.8% of solar photovoltaic energy generation also

Table 1.
Variation in energy demand in the world (between the first quarter of 2019 and 2020)

Energy source	Demand variation
Renewable	+0.8%
Nuclear	-2.5%
Natural gas	-5.0%
Coal	-7.7%
Oil	-9.1%

Source(s): International Energy Agency (IEA, 2020a, b)

comes from Northeast Brazil, according to ANEEL. These concentrations show Northeast as the main region for investment in renewable energies.

According to [Cavalcante \(2018\)](#), in the wind sector, the Sino-Brazilian relationship is built mainly on a commercial base. Early cooperation between the countries had already faced some challenges with issues of intellectual property rights and limited channels for technology transfer. While in China a variety of transfer channels are used, such as licensing and joint ventures, in Brazil the transfer is limited for multinational companies and their subsidiaries.

Despite recent, it is possible to identify some large investments. State Power Investment Corporation (SPIC), one of the five largest electricity generating companies in China, has two wind complexes located in the state of Paraíba and with an installed capacity of 58 MW, enough energy to supply more than 200,000 households annually. The two wind farms (Vale dos Ventos and Millennium) are in the Paraíba municipality of Mataraca and together comprise 73 wind turbines.

CTG Brazil, created in 2013, is a subsidiary of China Three Gorges Corporation (CTG), a world leader in hydroelectric energy production, with investments also in wind and solar energy. In Brazil, the company has 11 wind farms in operation, with a total installed capacity of 585 MW. More than 86% of all this installed capacity is located in the Northeast.

With the recent emergence of the solar energy market in Brazil, cooperation with China has just started. However, the relationship between the countries is already becoming closer - especially in the private sector. Most panels are imported from China and with recent governmental auctions for solar energy, many Chinese manufacturers are already considering establishing production in Brazil, as we will see later.

Among the companies that are already installed in Brazil, Build Your Dream (BYD), arrived in 2014. In 2016, BYD inaugurated a chassis assembly line for electric buses and assembly of rechargeable batteries and, the following year, a photovoltaic solar panel factory. This infrastructure enabled the partnerships with the government that came in the following years. Despite not being the largest market share occupied by the company, the production of photovoltaic solar panels received an initial investment of US\$29.2 million through a financing line from the National Bank for Economic and Social Development (abbreviated as the BNDES in Portuguese). Looking at the company's performance in renewable energy projects, BYD was responsible for 1 GW of solar panels delivered in Brazil until mid-2019, which corresponds to about one third of the installed capacity of the Brazilian market ([Tabak, 2020](#)). BYD, which aims to double the production of solar panels, competes in Brazil directly with a local unit of the Sino-Canadian company Canadian solar™. In addition to the production of solar panels, Canadian also operates in the energy generation sector.

In addition, Canadian Solar won several projects at the recent government auction, thus securing the demand to produce the panels. They have already planned the expansion of their module-assembly plant, as well as additional investments of US\$447 million ([Cavalcante, 2018](#)). In two auctions held in 2019, the company acquired three projects for photovoltaic solar plants, totaling 393.7 MW. One of the photovoltaic projects will be built in Pernambuco (190.5 MW), another one in Ceará (76.2 MW), and the third 127 MW project in the state of Minas Gerais, scheduled to start commercial operations before January 2023 ([Portal Solar, 2019b](#)). In the A-6 auction, Canadian Solar closed contracts for two photovoltaic solar energy projects that together add up to 150 MW. Also, the company will develop and build the Gameleira project of 120 MW in the state of Ceará and the Luiz Gonzaga project of 30 MW located in Pernambuco. With these contracts closed, Canadian has accounted for approximately 1.6 GW of contracted capacity since it started participating in the Brazilian market ([ANEEL, 2019](#)).

CGN Energy International, an investment branch of non-nuclear assets outside China General Nuclear Power, is one of the newest companies to enter the Brazilian clean energy market and has signed an agreement with the Italian energy giant Enel for a purchase of

100% of its new Gamma energy project in Brazil. The assets negotiated with the Chinese were the solar plants of Nova Olinda, with 292 MW, in the state of Piauí, and Lapa, of 158 MW, in the state of Bahia, two of the largest solar power plants in Brazil; in addition to the 90 MW Cristalândia wind farm, also in Bahia, totaling 540 MW of installed capacity.

In addition to these investments, these companies are focusing on new projects in the renewable sector, especially in Brazil's Northeast. Atlantic Energias Renováveis plans to invest more than R\$1 billion in the expansion of the Lagoa do Barro Wind Complex, in operation in Piauí, and in the construction of nine projects won by the company in the last big auction of ANEEL, which took place in October 2019. In the same auction, the company won the bid for generation of 218.5 MW in the wind farms Aura Tanque Novo 1, 2 and 3, and Aura Caetité 1, 2, 3 and 4 in Bahia, and Aura Queimada 1 and 2, in the state of Piauí, according to ANEEL.

SPIC plans to invest R\$4 billion in the Northeast, of which BRL 2 billion in Rio Grande do Norte, in the production of wind and solar energy. The Chinese state-owned company also intends to install a technology development and improvement center in Rio Grande do Norte and a factory of products and inputs for power generation (Brazil Windpower, 2019). In the same direction, CGN also aims at the market in Rio Grande do Norte and studies the installation of the unit in the factory (Portal Solar, 2019c). The company Chint Eletrics Co., which has not yet made major investments in Brazil, foresees the installation of a factory to produce photovoltaic panels, inverters and components for the production of energy through the capture of solar radiation in the state of Rio Grande do Norte (AGORA RN, 2019).

In summary, the Chinese presence in the renewable energy generation sector in Northeast Brazil is concentrated in the companies CGN, CTG, SPIC, Atlantic Energias Renováveis, and Canadian Solar, complementing with the production of photovoltaic panels from the latter and BYD. The table below summarizes the numbers presented above and includes assets in which the companies under analysis are participants but are not the majority shareholders (see Table 2).

Considering all the power generation assets in the sector, the Chinese companies analyzed have 143 projects (among those under construction, in operation or with construction to be started) that total 4 GW of power granted by ANEEL. As we can see in Figure 1, most of the projects in the Northeast are aimed at generation of wind power.

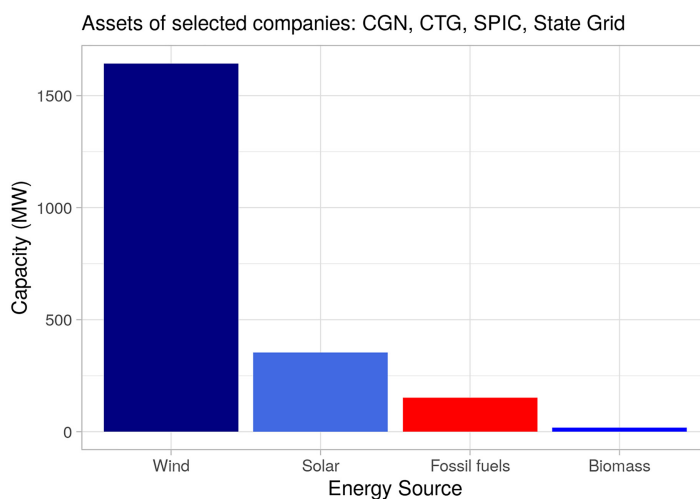
When we consider all regions of Brazil, these same companies stand out in the participation of assets in hydroelectric generation (Figure 2). Through mergers and acquisitions, China has gained space in the Brazilian energy sector. Some examples are the plants of São Simão, in Pará, and Santo Antônio, in Rondônia. In total, there are 219 projects with 8.94 GW generation power.

As we can see, there is an increasingly significant presence of Chinese companies in the Brazilian energy market. Despite the challenges to be faced due to the expansion of investments in renewable sources, the support policies developed by the Brazilian government were important in this process, namely social inclusion programs, solar and wind energy auctions, net-metering systems and financial and fiscal incentives. However,

Company	CTG	CGN + Atlantic Energias Renováveis	SPIC	State Grid	Canadian Solar
Number of projects	40	38	11	45	8
Power granted	1,47 GW	1,04 GW	58 MW	1,27 GW	225 MW
Location (states of Brazil's Northeast)	Rio Grande do Norte	Piauí, Bahia e Rio Grande do Norte	Paraíba	Ceará e Rio Grande do Norte	Pernambuco e Ceará

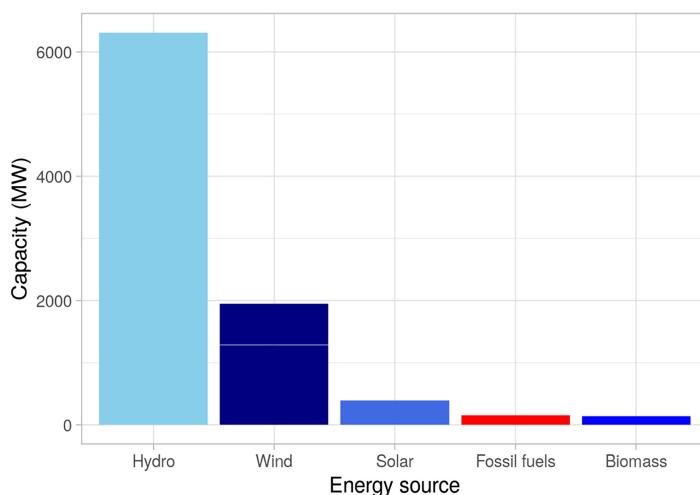
Source(s): ANEEL

Table 2.
Chinese investments in solar and wind energy in the Northeast of Brazil



Source(s): ANEEL, 2020

Figure 1. Installed capacity by energy source – Northeast Brazil



Source(s): ANEEL, 2020

Figure 2. Installed capacity by energy source – Brazil

Brazil still needs to move forward in different fields, such as taxes, logistics, energy costs, wages, and others.

It is important to consider that the energy outlooks of both countries suggest that there is a large window of opportunity for unexploited energy cooperation. China is a leader in solar energy and Brazil actively invests in the sector's growth. Not only financial and trade variables should be taken into consideration in this matter. According to Oliveira (2016), the Chinese-Brazilian energy cooperation lacks a framework agreement that encompasses trade, equipment supply, and technological services for the energy companies considering energy security and climate change objectives. Technology transfer channels are still not well

developed and need to be incorporated into Sino-Brazilian cooperation. Nevertheless, Brazil is inserted in a very favorable scenario for the expansion of investments in renewable energies considering its great potential, which makes the Brazilian market very promising and sympathetic to the expansion of the assets of Chinese companies.

6. Conclusions

Brazil presents an attractive market, providing business opportunities in the energy and infrastructure sector. Even though the country fosters a propitious environment to develop trade partnerships with China, the country is not formally a member of the Belt and Road Initiative (BRI).

Despite the big share of renewable energies in Brazil, the current installed matrix is focused on hydroelectric sources, which face several problems to its expansion. However, Northeast Brazil has a large potential to implement wind and solar sources, growing fast over the years. In this scenario, Chinese companies would practically dominate this initial market, both in direct investment and in the supply of raw material.

In this sense and considering the context of economic and geopolitical transformations in the world, in addition to regional aspects, this article points to the need to rethink mechanisms, instruments, and regional institutions that can be mobilized to promote the development of Northeast Brazil. One of these regional institutions is the Northeast Consortium, as mentioned in the introduction of this paper. Despite having been constituted a few years ago, the Consortium has presented itself as an instrument that can leverage regional development, especially Sino-Brazilian trade relations, which can be boosted through regionalized trade and investments.

Once the Consortium starts to further develop the region and divergences with the federal government emerge, the creation of a para-diplomacy with China should be interesting to leverage Foreign Direct Investments and transfer of technology from large Chinese corporations, such as BYD and CTG.

For this end, the Consortium could clearly show the high potential of wind and solar sources, especially due to the limitations of the hydroelectric matrix in the longer drought periods that Brazil has been facing recently. The first steps have already been taken, but it is important to keep track of them to enable the use of the full potential of these two sources, consequently developing the whole economy through greater energy supply and less dependence on other sources.

There is no doubt that China's successful experiences in deploying and diffusing renewable technologies are becoming increasingly attractive to other developing countries. The bigger share of the value and prosperity in the global commodity market is associated with the development of strong Chinese brands and companies in the value chain. The transition from early comparative advantages perceived through the large amount of cheap labor and low environmental and land costs to the current astonishing performance in outbound direct investment entails ownership of leading-edge industrial technologies, either developed internally or obtained from others.

Today, Brazil-China cooperation on the development of renewable energy is focused on trade and investment, not technology transfer. However, with the deepening of the cooperation and the improvement of capacity in all aspects (human, institutional, financial), especially on the Brazilian side, the process of technology transfer is an unavoidable issue along with trade and investment policies.

The aim of this article was to better understand the dynamics of the Chinese presence in the renewable energy sector, focusing on Northeast Brazil due to its relevance in the sector and mechanisms of regional development. For future research, we suggest the assessment of how the Northeast Consortium could take advantage of possible benefits from a membership

in the Belt and Road Initiative or other collaborative actions with China. Another possibility could be to assess how the dynamics observed in this article could be taken to other Brazilian regions or to other economic sectors.

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