BOSTON UNIVERSITY Global Development Policy Center

GCI WORKING PAPER 012 • 12/2020

New Kids on The Block
China's Arrival in Brazil's Electric Sector

PEDRO HENRIQUE BATISTA BARBOSA[1]

Pedro Henrique Batista Barbosa *is a Global China Initiative Fellow at the Global Development Policy Center, PhD candidate in international politics at Renmin University of China and Brazilian career diplomat. He specializes in Brazil-China political-economic relations, focusing mainly on four pillars: trade, investments, infrastructure projects, and loans.*

ABSTRACT

Chinese presence in the Brazilian electricity sector has increased consistently and significantly in three aspects: investments, construction projects and loans. Over the last two decades, Chinese investors, manufacturers, engineering services' providers, and financial institutions have poured considerable amounts of capital in Brazil. Benefiting from a continuous internationalization process in the local generation, transmission, and distribution segments, they have become the leading foreign players operating in the country in a short time, displacing other traditional external actors. Behind this push, there is a complementarity in renewable energy. Brazil's rich resource endowment, necessity to expand installed capacity and power grid, and favorable market, legal, and policy conditions, aligned with China's financial might and technological capabilities, have created an ideal situation for Chinese firms' arrival. Not only China became relevant to Brazil`s electricity development plans, but the South American country had an important role in Chinese companies' global push. Brazil concentrates the biggest part of these firms' overseas power generation capacity. Some of these corporations, such as State Grid and CTG, have the majority of their external assets in Brazil. This paper aims to understand how deeply China has penetrated Brazil`s electricity sector and how this process has evolved over time. It identifies the main actors, describes their activities and analyzes the extent to which Brazil and China have inserted themselves in each other's global energy strategy.

KEY WORDS

Brazil. China. Energy cooperation. Electricity. FDI. Construction projects. Finance.

[1] PhD candidate in international politics at Renmin University of China and Brazilian career diplomat. The opinions expressed here do not reflect those of the institutions the author is affiliated to.

TABLE OF CONTENTS

INTRODUCTION

- Over a relatively short span of time, Brazil-China energy cooperation has reached new heights. Three sectors have experienced a growing engagement of Chinese energy corporations: oil and gas (O&G), renewable energies, and transmission. In the particular case of electricity, mainly from 2010 on, Chinese investors, manufacturers, engineering services' providers, and financial institutions have poured considerable amounts of capital in Brazil and have become one of the main players in the country and the leading foreign actors.

- Reasons for this phenomenon abound. Among the chief ones, there is a complementarity between the countries in renewable energy. Brazil's rich resource endowment, necessity to expand installed capacity and power grid, and favorable market, legal, and policy conditions, aligned with China's financial might and technological capabilities, have created an ideal situation for Chinese firms' arrival. Brazil's continuous expansion of electricity demand and supply over time was another strongpoint.

- In a global perspective, particularly after the 2008 worldwide crash, China has become a major and active investor in the international electricity sector, either in the form of mergers and acquisitions (M&A) or greenfield projects. In some specific sectors, such as power generation, the country was the number one in some years. Electricity-related finance has expanded alike, under the directives of the policy banks China Development Bank (hereinafter CDB) and Export-Import Bank of China (Exim). Both the investment and the financial side of this international expansion have been highly documented and deeply discussed in academic works and media reports. Brazil was one of the top targets of Chinese electric companies, one of main destinations of Chinese equity investments and banking services.

Concomitant with the increasing number of projects and values invested by Chinese energy firms in Brazil, an upsurge of academic publications and media reports about this phenomenon has followed suit. Some have concentrated their analysis on certain projects or companies' activities[2], others have emphasized specific sectors – generation, transmission and distribution – or sources of energy[3] – hydroelectric, wind, solar, coal, biomass, oil etc. –, and a few have analyzed the political, economic and environmental implications of the new trends.[4]

The recent growth of studies notwithstanding, there is still lacking a comprehensive work that depicts the activities of Chinese electric corporations in Brazil and that searches for the main drivers behind them. In other words, the actual extent of China`s penetration in the country's electric sector in each of its segments and sources of energy is not well known. Little has been discussed about the number and installed capacity of power plants, kilometers of transmission lines, and quantity of electricity consumers that are under Chinese investors' control, nor is there a through picture of the percentage of these assets in the total electric sector. Geographic analyses are equally missing, in which one sees the distribution of projects across the country, in each region and state.

[2] Leite and Vanderlei (2017), Cote (2014), Cui and Zheng (2019), Hiratuka (2018), Vanderlei (2018), Barbosa, Tepassê and Biancalana (2014), and Proença and Kupfer (2018) study State Grid's activities. Proença and Kupfer (2018) examine China Three Gorges' investments as well.

[3] Hochstetler and Kostka (2015) and Cuperstein (2014) examine the wind and solar sectors. Xu (2019) analyses the bilateral cooperation in renewables. Cavalcante (2018) focuses on solar energy.

[4] Silveira (2018) assesses the Chinese state-owned energy enterprises investments in Brazil and their strategic interest in the Amazon. Tang (2017), Da Silva (2019), Becard and Macedo (2014), Ferreira, Santos and Neves (2019), and Schutte and Debone (2017) write about Chinese investments in the electric sector as a whole. Husar and Best (2013) discuss the possibility of technology cooperation between Brazil and China in the electric sector. Becard, Lessa and Silveira (2020) emphasize the political and economic impacts of Chinese investments in the electric sector.

This paper aims at bridging this gap and examining the Chinese investments and loans in Brazil's electric sector, more specifically in hydro, wind, solar, coal, biomass, oil, and nuclear power segments[5] from their onset in mid 2000's until 2019. It also provides estimates of Chinese firms' installed capacity, kilometers of transmission lines and number of consumers connected to their investments in Brazil. Additionally, this study intends to assess these investments from three perspectives: the role of Brazil in China's global electric activities, the expansion of Chinese companies in the country's electric sector and their performance in comparison with other international players. To have this kind of broad picture can be a useful tool to further case studies and also to develop business assessments and governmental analysis on foreign investments in the country.

Undeniably, the magnitude and speed of Chinese engagement in Brazil's electric sector have triggered many questions among scholars, policymakers, and the general public, for instance: why and how did these investments evolve? What are the main elements and drivers of this recent push? What are the main actors involved? Will these investments last, for how long? These and other queries are going to be debated in this article, an effort will be made to provide reasonable answers.

Some findings of this work are:

- China's engagement in Brazil's electric sector has three pillars: FDI, construction projects and loans.
- US$36.5 billion were spent in FDI and construction projects by 2019.
- Most of it entered the country in the form of M&As (76 percent).
- State Grid alone is responsible for more than half of all FDI (56 percent), followed by CTG (27 percent).
- State Grid and CTG have the majority of their overseas investments in Brazil.
- State-owned enterprises (SOE) have provided most of the capital (98 percent).
- Chinese companies invested where Brazil has a natural advantage or an abundance of resources. Hydroelectric has received 81 percent of all generation investments.
- Power generation has received four-fifths of China`s total power sector investments in Brazil (81 percent).
- Sao Paulo is the preferred destination.
- Chinese companies own or partially own 304 power plants, which total 16,736 MW, or 10 percent of the national generation capacity.
- 70 percent of China's installed capacity is in hydroelectric generation, and CTG is the second major electric generator in Brazil, after Eletrobras.
- 48 percent of Sao Paulo's hydropower generation capacity is in the hands of Chinese firms.
- There are 16,776 km of Chinese-owned transmission lines, or almost 12 percent of the national length.
- Roughly 126 million consumer units, or 12 percent of local distribution sector, receive energy from Chinese firms.

[5] Oil & gas, geothermal and others are not included here.

- Loans from Chinese policy-banks, regional funds and multilateral banks in which China is a leading member amount to US$1.7 billion.
- Chinese commercial banks provided another US$1.2 billion.
- Lastly, Brazilian financial institutions' contribution was US$3.1 billion.

CHINA'S ENERGY INVESTMENTS AND FINANCE GO GLOBAL

The energy sector has been an important part of China's global investment and finance expansion under the "going out" strategy. Over the last two decades and especially after the 2008 economic crunch, Chinese oil & gas (O&G) and electricity companies, along with machine manufacturers and service suppliers, went on an international spree that reached nearly every continent. Backing them, there was the financial might of Chinese policy banks, increasingly active as providers of financial solutions to energy ventures. These phenomena were not absent in the specialized academic literature, which dissected their three pillars: Chinese outward foreign direct investment (COFDI) – through cross-border greenfield and brownfield endeavors[6] –, construction projects and finance.

Many scholars have analyzed the global activities of Chinese energy companies. Gopal et al (2018) examined China's global emergence in energy investments and concluded that they represented 5 percent of the world's total between 2003 and 2016. Chinese greenfield projects were focused on electricity generation and transmission, and brownfield ones were concentrated in oil extraction, with increasing amounts invested in electricity generation in the last few years of the period. The preferred recipient countries were Australia, Brazil and Portugal for M&As and China's Asian neighbors for GFDI. In electricity generation, transmission and distribution, they estimated that US$108 billion had been invested.

Kong and Gallagher (2017) estimated that COFDI in the energy sector reached US$258 billion between 2000 and 2014. Of this total, 82 percent has happened in the form of brownfield, with a concentration in the period after the 2008 crisis and in fossil fuels. Greenfield projects occurred mainly in emerging economies, while M&A were seen mostly in industrialized economies.

Li, Gallagher, and Mauzerall (2018) focused on Chinese investments in the electric power sector. According to them, between 2000 and 2017, Chinese firms hold US$115 billion in electric power assets globally. This refers to 462 power plants abroad, whose total generation capacity is 81 GW. State-owned enterprises (SOEs) were the dominant investors. Projects boomed after 2008. In the whole period, most of the capital went to coal and hydropower sectors and to emerging countries in Asia and Latin America. In the last four years, Brazil was the preferred destination and it is where Chinese companies acquired the biggest quantities of installed capacity. Yet these numbers are still relatively small when compared with the total national system. In some countries, such as Cambodia, Chinese players represent almost 80 percent of the local capacity. Additionally, almost half of the GFDI went to coal plants, whereas gas and hydro dominated the M&A. In recent years, renewables sources have received the bulk of the investments.

Cabré, Gallagher and Li (2018) presented new estimates and calculated US$216 billion invested in overseas plants, with a total of 158GW of installed capacity. Of this total, around US$101 billion is related to Chinese policy banks.

[6] Greenfield (GFDI) refers to new projects, and brownfield indicates mergers and acquisitions (M&A).

Boston University's Global Development Policy Center (GDPC) shows updated numbers for Chinese firms' total or partial ownership of overseas plants. Through 2018, Chinese companies and financial institutions were involved in projects abroad of 186.5GW of installed capacity, distributed through 777 plants. Asia concentrates more than half of the generation capacity with Chinese capital participation, followed with Latin America and Africa. Individually, Brazil, Pakistan, Indonesia and Vietnam were the main targets. Chinese firms' GFDI and M&A transactions amounted to 51 GW and 47 GW respectively. These companies invested an additional 19 GW with the financial backing from CDB and CHEXIM. Further 69 GW are related to plants that were financed by these two policy banks. In terms of resources, coal related projects rank first, followed by hydro (Gallagher, et al., 2019).

Chinese energy finance has also been examined in a series of studies. Kong and Gallagher (2017) asserted that China became the world's leading provider of energy finance to other governments, a movement spearheaded by CDB and CHEXIM. Between 2005 and 2014, they channeled US$128 billion to energy projects all over the globe, almost matching the amount provided by other major Western-backed multilateral developments banks, such as the World Bank and the Asian, the African and the Inter-American Development Banks.

Gallagher et al (2018) evaluate that China's energy development finance reached US$226 in the 2000-2017 period. These loans were extended to all continents, engaging with higher risk-rated countries, which were usually unable to access traditional banks' long-term energy financing. China secured almost half of these loans with commodity-backed clauses, in which the repayment is made in the form of commodity sales, mainly oil. Most of these funds went to the power generation sector, in which coal and hydro projects were the main targets. In another academic piece, Kong and Gallagher (2020) explored the reasons why solar and wind projects have received only a small fraction of China's world-wide finance (2.6 percent).

In more recent works, Ma, Gallagher, and Guo (2019) brought updates on the total amount of China's global energy finance. Until 2019, CDB and CHEXIM provided no less than US$251 billion to energy projects all over the world. Like in the number of plants owned by Chinese firms, the majority of the funds went to Asian countries, with Africa and Latin America running in the second and third places. Individually, Russia, Brazil and Pakistan were the main benefactors. Oil related ventures received almost one-third of the total, being followed by coal and hydro projects.

Lastly, it is important to pinpoint that this international expansion of Chinese electric firms had political backing. For example, China's 13th Five-Year Energy Development Plan, which set targets for energy development in the 2016–2020 period, explicitly promotes international cooperation in the field (NEA, 2016 p. 8). National companies are encouraged to participate in foreign major power projects (Becard, et al., 2020 p. 69).

JOINING THE CLUB: CHINESE INVESTMENTS IN BRAZIL'S ELECTRICITY SECTOR

Capital invested

This study has identified at least 14 Chinese electric companies that were or are investing or operating in Brazil, including announced deals so far. Some of these companies reportedly have already left the country or pulled back their investments. Some of the announced deals could not be confirmed. Some companies have stakes in different segments and sources of energy, such as State Grid, that invests in generation, transmission and distribution, and China Three Gorges (henceforth CTG), which has projects in hydro, wind, solar and coal.

Table 1: Chinese electricity firms in Brazil

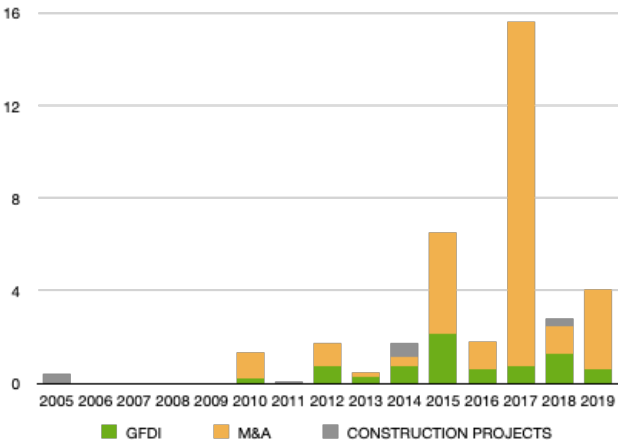
Generation			Transmission	Distribution
State Grid	CTG/EDP	CGN	CEE Power	State Grid
CLAI Fund	China-Portuguese Speaking Countries Fund	Zhejiang Energy	Zhejiang Insigma United Engineering	
SPIC	CITIC	CLAC Fund	State Grid	CTG/EDP
Canadian Solar	COFCO	Jiangsu CCETC	CTG/EDP	

Sources: multiple.

These companies have invested and were involved in construction projects in Brazil that amount to US$36.5 billion until 2019. Chinese electricity companies' inaugural project in Brazil happened in 2005, when CITIC was hired to build Phase C of the coal plant Presidente Medici (also known as Candiota III), in a US$428 million contract (SECEX, 2006). After that, investments restarted their upwards trend in 2010, when State Grid disembarked in the country. From 2015 on, there was a significant increase in numbers, with peaks in 2015 (US$6.5 billion) and 2017 (US$15.6 billion), mainly due to deals pioneered by State Grid and CTG. In 2015, the former won alone the bid for the second transmission line of the Belo Monte dam, a project that demanded roughly US$1.78 billion (Aneel, 2015). In the same year, CTG spent US$3.7 billion to buy Jupia and Ilha Solteira dams (Aneel, 2015) and became the country's second biggest electricity generator.

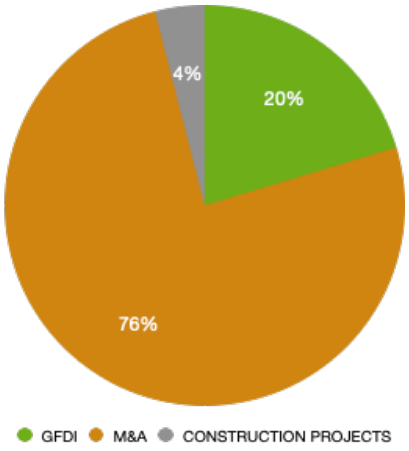
In 2017, State Grid disbursed around US$12.2 billion to acquire the absolute majority of the shares of the Companhia Paulista de Forca e Luz (henceforth CPFL) (CPFL, 2017) (Boadle, 2017), inaugurating a new phase of the Chinese firm history in Brazil. From then on, State Grid, whose business is traditionally on transmission, expanded to generation and distribution. This deal, which was the single biggest transaction by a Chinese energy firm over the period of this study, was a strategic and milestone move of State Grid in Brazil. The CPFL group was already a successful and well-established corporation. In 2019, CPFL was the third biggest private agent in Brazil's generation sector – and the ninth including public ones (Aneel, 2020). CPFL Renovaveis was the number one in Latin America in terms of production from alternatives sources of energy (CPFL, 2019).

Figure 1: Chinese FDI/construction projects (US$billion)



Source: multiple.

Figure 2: types of investment (2005-19)



In September 2017, the State Power Investment Corporation (henceforth SPIC) arrived in Brazil and won the bid for the Sao Simao hydropower dam in a consortium with other Chinese institutions. US$2.3 billion was paid (Aneel, 2017). A few months before, it acquired Pacific Hydro Brasil, a company with solar and wind farms, in a transaction whose financial details were not disclosed (PacificHydroBrasil, 2017).

In terms of mode of entry in Brazil, Chinese companies mostly resorted to M&A. Brownfield projects represented 76 percent of the total, or US$27.6 billion. Except in 2013, 2014 and 2018, brownfield deals' numbers were higher than greenfield ones in all years. The highest numbers were spent in 2015, 2017 and 2019. In the former year, the abovementioned acquisition of Jupia and Ilha Solteira dams took place. In 2017, State Grid's purchase of CPFL and SPIC's buying of Sao Simao dam pumped up the M&A' figures. In 2019, China General Nuclear Power Group's (herein CGN) arrival in the country's wind power market (Enel, 2019) and the selling of the Peruvian Chaglla hydropower dam from Brazilian construction firm Odebrecht to CTG (US$1.4 billion) (Odebrecht, 2019) inflated the figures of the year.

GFDI amounted to 20 percent of the total, or US$7.4 billion. M&A alike, greenfield deals started in 2010, when Zhejiang Insigma United Engineering, in partnership with local firms, won the bidding process to build transmission lines in the southern Rio Grande do Sul state (Aneel, 2020). Peaks occurred in 2015 and 2018. In the first year, the already mentioned State Grid's successful bid of the Belo Monte dam's second line took place. In the second year, State Grid's and CTG's controlled companies CPFL and EDP Energias do Brasil (hereinafter EDP) and EDP Renovaveis Brasil (henceforth EDP Renovaveis or EDPR) respectively participated and won a series of Aneel's bids in the generation and transmission sectors.

In December 2011, CTG overbid the German E.ON and the Brazilian consortium CEMIG and Eletrobras and acquired 21.47 percent of the Portuguese electric company Energias de Portugal for US$3.5 billion (Bugge, 2011). CTG, therefore, became the major single investor of EDP, followed by North-American investment funds and minority stakeholders. With this transaction, CTG entered the Brazilian energy market. EDP has the controlling stakes of EDP Energias do Brasil and EDPR.

Engineering projects and other services provided by Chinese companies amounted to 4 percent of all capital disbursed, or approximately US$1.5 billion. Besides the already cited CITIC's EPC contract to build part of the Candiota coal plant in 2005, many other contractors came to Brazil, some for specific projects, others in a longer-term strategy.

Examining the mode of entry in the company level, M&A is still the preferred way. Of the approximately US$19.6 billion that State Grid and its affiliated companies invested in Brazil, US$15.4 billion were in the form of M&A, roughly 78 percent. CTG's experience in the country is not different, out of the US$9.7 billion invested, US$7.7 billion were in brownfield projects, or 79 percent. CGN dispatched US$2.1 billion to the country, US$1.85 billion through M&As. Other firms, such as SPIC, Zhejiang Energy International and Jiangsu CCETC, exclusively made use of M&A.

It is possible that this pattern of concentration in M&A has some correlation with the source of energy. Hydropower is Brazil`s most used one over history and has little expansion potential, comparing to other sources. Therefore, investments in this sector tend to be brownfield. In contrast, investments in other renewables, such as solar, are still below the country's potential, a situation that fosters GFDI projects.

Another reason for the inclination towards buying locally established corporations, no matter national or international, is a strategy of reducing business risks, avoiding conflicts with regulators and other competitors, and enhancing corporate efficiency. Local firms are already acquainted with

Figure 3: Chinese FDI per company (US$)

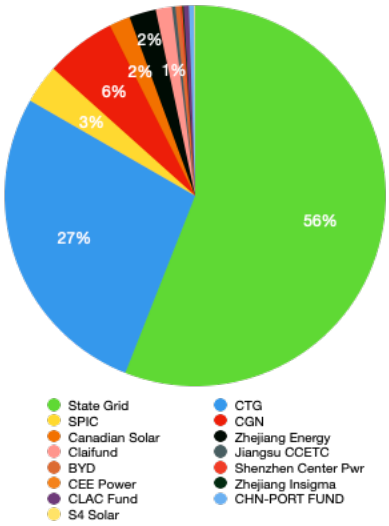
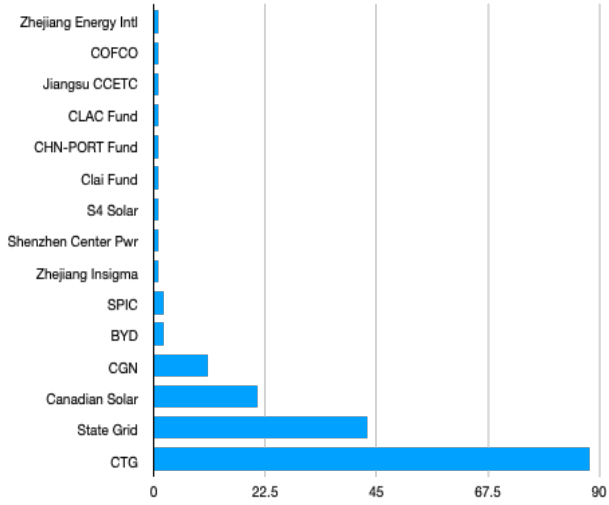


Figure 4: Number of projects/deals



Source: multiple.

local norms, tax system, and sectoral regulations, are experienced with government's bureaucracy, are well connected with the native labor force and supply chains and have deep technical knowledge in their fields. Buying them is a secure first step to Chinese companies in a brand-new environment.

Considering only FDI projects, there were 176 transactions.[7] Since CTG is indirectly present in Brazil since the end of 2011, when EDP was acquired in Portugal, it has the greatest quantity. EDP Brasil, EDPR and others were involved in several research and development (R&D) projects, whose values invested are usually small, and in wind farms, which typically have a higher number of facilities. The same is the case of State Grid, which has 43 transactions. Since 2017, CPFL, CPFL Renovaveis and others have invested in R&D plans and wind power ventures.

Of the total FDI investment, State Grid was the biggest spender, reaching 56 percent. CTG disbursed 27 percent, CGN 6 percent, and SPIC 3 percent. Although State Grid is originally a transmission company, responsible to transmit energy to 88 percent of the Chinese territory (Proenca, et al., 2018 p. 281), in Brazil, it invested 69 percent of the company's total in generation, mainly because of CPFL's acquisition.[8] Distinctively, CTG's allotted money in Brazil went almost completely to power generation, the same situation of CGN and SPIC.

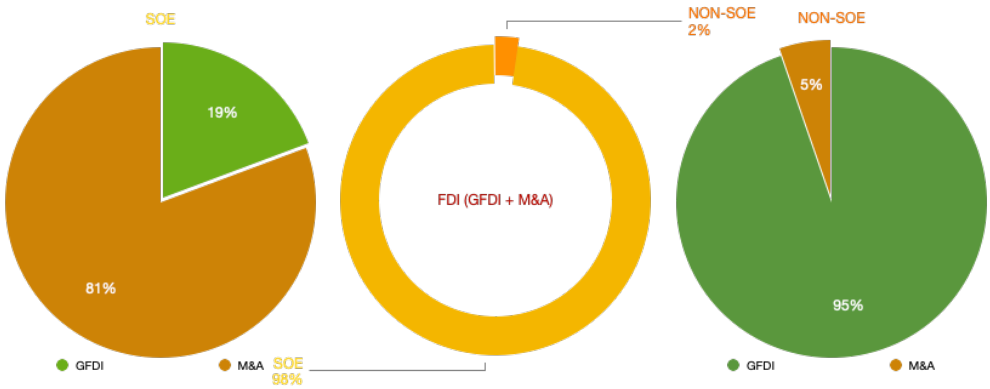
Categorizing the ownership of these companies, the absolute majority of investments came from SOE[9] (98 percent). Chinese SOE, in fact, are the chief investors in the overseas electric market, which is a unique feature of Chinese investments vis-a-vis western players (Li, et al., 2018 p. 8). Intriguingly, SOE and non-SOE have chosen different ways to invest in Brazil. Whereas SOEs mainly made use of M&A (81 percent), non-SOE have preferred new projects in the country (95 percent).

[7] GFDI projects are counted per project/plant/transmission line, whereas M&A are calculated per deal, no matter how many dams or lines are included in the agreement.

[8] Although CPFL has investments in transmission and distribution, the values involved in its purchase were considered as generation in this research.

[9] State Grid, CTG, CGN and SPIC are central SOEs, directly supervised by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) (SASAC, 2020). Zhejiang Energy Brazil belongs mostly to Zhejiang Province's SASAC (Aneel, 2020). CCTEC Brazil belongs to the provincial government of Jiangsu (CCTEC, 2020).

Figure 5: SOE and NON-SOE investments' mode of entry



Source: multiple.

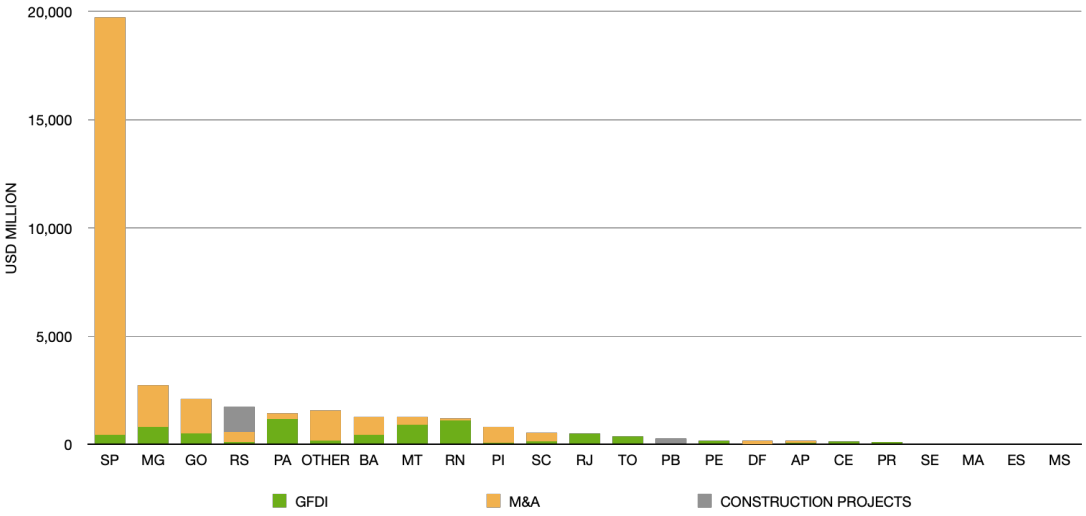
It is interesting to put the values disbursed by Chinese companies in a global perspective. For this purpose, we consider only the numbers spent directly by these firms in Brazil, not including their subsidiaries' projects, and compare them with the data shown in FDI Intelligence for greenfield and DeaLogic for brownfield deals. In this sense, State Grid has allocated US$19.2 billion in Brazil, which would be 48 percent of the approximately US$40 billion it has invested in GFDI (fDiIntelligence, 2019) and M&A (DeaLogic, 2019) all over the globe. Similarly, the US$7.9 billion that CTG assigned to Brazil represents nearly 60 percent of the US$13.3 billion it invested abroad over the years. About CGN, its US$2.1 billion in Brazil represents 31 percent of the global US$6.7 billion invested. For SPIC, the US$1.2 billion related to its shares in the Sao Simao dam accounts for 17 percent of the US$6.8 billion spent worldwide.

Analyzing the geographical distribution of FDI and construction projects, Chinese firms are active in all Brazil's five macro-regions, 22 states in total. The Southeast received 66 percent of the total invested, especially because Sao Paulo's (SP) was the major destination of funds. Since this region concentrates 28 percent of the national installed capacity, has the highest number of consumers (28 millions in 2018, or one-third of the whole) (EPE, 2019) and 52 percent of the country's GDP (IBGE, 2020), it is a natural investment choice to any investor.

The Northeast came in second with 11 percent and this is because of the predominance of the region in solar and wind generation projects, which attracted increasing investments in the last few years, not only from Chinese investors. The Central-West occupied the third place with 10 percent. Here is where there was a great expansion of local transmission lines over the last years. Moreover, through these states crossed two of the longest lines built in Brazil recently: the Belo Monte dam ultra-high-tension lines, with more than 4.6 thousand kilometers. Besides these two lines, State Grid has other transmission projects there.

The South and the North have 7 percent and 6 percent respectively. Southeast alike, Southern states have a well-developed electric system and is where Chinese acquired companies' such as CPFL, EDP and Celesc – bought by CTG in 2018 (EDP, 2018) – have big stakes. The three Southern states of Parana (PR), Rio Grande do Sul (RS) and Santa Catarina (SC) have 19.4 percent of the total installed capacity, the third place in the quantity of consumers (12.5 million, just after the Northeast) (EPE, 2019), and 17 percent of the national GDP (second place, just in front of the Northeast with 16 percent). Besides the well-explored hydropower potential over the Parana River, the region has potential for wind and coal generation.

Figure 6: Chinese FDI/construction projects per state (2005-2019)



Source: multiple.

Finally, the North is a new frontier for the expansion of electric generation, thanks to its relatively unexplored potential in hydropower. It is poised to receive more greenfield investments from all actors in this source of energy and in transmission lines in the future.

In terms of states, Sao Paulo received the majority of the capital invested, more than half of the whole (US$19.7 billion). Of this total, 98 percent is of M&A. In the state, around two-thirds of all brownfield deals took place. Contributing to this figure was State Grid's acquisition of CPFL and CPFL Renovaveis – a transaction that involved US$13.3 billion – and CTG's purchase of Jupia and Ilha Solteira and of 100 percent of Duke Energy's 28 assets in Brazil, most of them in that state. It is in Sao Paulo where some Chinese companies decided to open representation offices and manufacturing facilities. BYD has a solar panel factory in the city of Campinas (Apex, 2017). Canadian Solar inaugurated, in collaboration with Flex Energy, a solar module facility in Sorocaba (Lopez, 2016). Nari Brasil has its headquarters in Sorocaba (Nari, 2020), while Trina Solar in the city of Sao Paulo (Costa, 2017). Shenzhen Center Power bought the majority of the shares of Unicoba Baterias, for US$46 million (Fusoes&Aquisicoes, 2017).

Sao Paulo also concentrated almost half of the total amount of Chinese investments in R&D (US$26 million), as data released by companies and Aneel show. It is worth mentioning that, according to Brazilian law, all active companies in the country's electric sector must use part of their revenue in R&D projects (Aneel, 2020). CTG's and State Grid's controlled companies EDP and CPFL respectively are the main investors among the Chinese firms.

Running second comes Minas Gerais (MG), with more than US$2.7 billion of investments, once again two-thirds as brownfield. Goias (GO) comes after with US$2.1 billion. In the border of these two is the big Sao Simao dam, which belongs to SPIC, Zhejiang Energy International, CLAI Fund and China-Portuguese Speaking Countries Cooperation and Development Fund. Some of the transmission lines bought by State Grid cross Goias. Canadian Solar, a Sino-Canadian firm, has acquired 22 solar in MG through its participation in different auctions, over the last years. It still owns 11 of them.

While Sao Paulo leaded in M&A, Para (PA) and Rio Grande do Norte (RN) led in GFDI. Each state received US$1.2 billion and US$1.1 billion respectively, followed by Minas Gerais with US$822

million. Sao Paulo received about US$458 million. Para is the starting point of Brazil's recently built big hydropower dams, such as Belo Monte, whose two lengthy lines were built and are operated by State Grid. The Santo Antonio do Jari dam is also located there and is jointly owned by CTG and EDP (MarketScreener, 2013). Rio Grande do Norte is the Brazilian state with highest potential for wind power generation and, consequently, attracted investments from national and foreign companies. CPFL Renovaveis and EDPR both own several wind farms there, as well as CGN and SPIC.

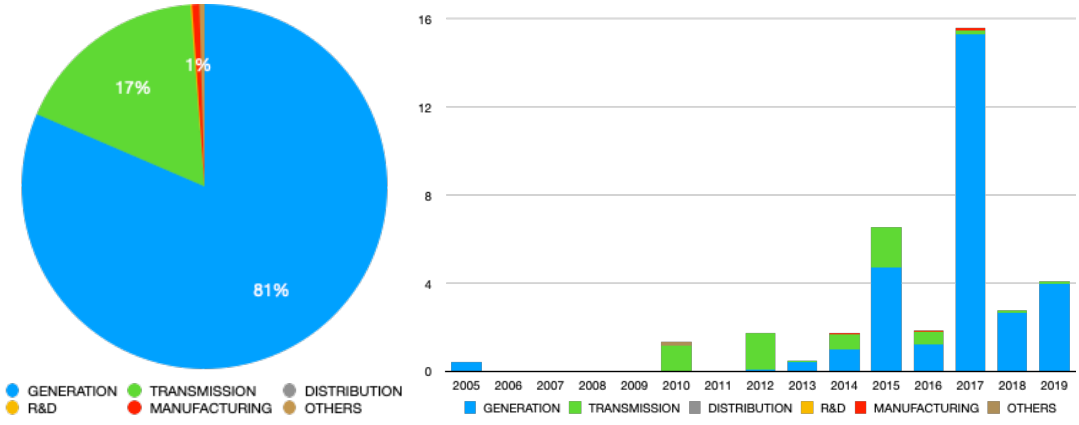
Distinctively, Rio Grande do Sul concentrates nearly 80 percent of the construction projects pioneered by Chinese firms (US$1.1 billion). Over the years, several of these firms were responsible for performing a wide range of services there, from designing and constructing plants, to reforming and giving maintenance. Coal power stations were the preferred target, since the region concentrates almost the totality of Brazil's coal reserves and related projects.

Putting the figures above in comparison with Chinese FDI in all economic sectors over the last years, there are some remarkable similarities. Reports from the Brazilian Ministry of Economy (CAMEX, 2019), the China-Brazil Business Council (CEBC, 2019) and Cechimex (RedALC, 2020) about Chinese investments in Brazil all show similar trends. Chinese FDI inflows increased substantially from 2010 and especially in the last few years of the period. They are essentially concentrated in the energy sector, and electricity was the main target in the last few years. According to the Brazilian government, 45 percent of China's total investments in Brazil are in the electric sector (CAMEX, 2019 p. 12). In the 2014-2017 period, the electricity sector accounted for almost 75 percent of all investments (Hiratuka, 2019 p. 179). In addition, the most common mode of entry is M&A, and the preferential location is the state of Sao Paulo.

In terms of energy investment sectors, Chinese firms have showed preference for generation, which encompassed 81 percent of the total or roughly US$29.7 billion. Almost all deals happened in the last six years of the period, with the highest numbers in 2015, 2017 and 2019, because of CTG's, State Grid's and CGN's brownfield transactions respectively. Of the total amount in generation, State Grid and its companies were responsible for 48 percent, CTG and its affiliates 33 percent, CGN 7.5 percent, and SPIC 4 percent.

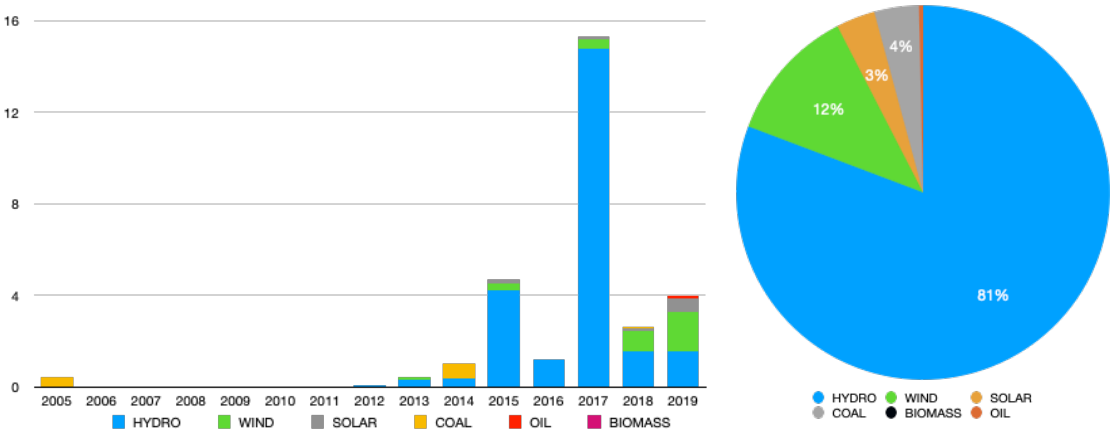
Transmission deals amounted to US$6.3 billion or 17 percent. Most of the projects happened in 2010, 2012 and 2015. State Grid accounted for 95 percent of this total or around US$6 billion. CTG's share was 4.2 percent, all through EDP and Celesc.

Figure 7: Chinese FDI/construction projects per sector (US$billion)



Source: multiple.

Figure 8: Chinese FDI/Services per source of energy (US$billion, generation)



Source: multiple.

There were no distribution projects identified in the period. Chinese companies' participation in this sector is through the acquisition of local firms that also invest in it, but not exclusively.

Manufacturing projects were of US$235 million, 1 percent of the total. The US$134 billion spent by BYD in its solar panel factory represented 60 percent of whole. Lastly, R&D projects were up to US$56 million, mostly spent by State Grid's companies (75 percent), mainly CPFL, and CTG's EDP (25 percent).

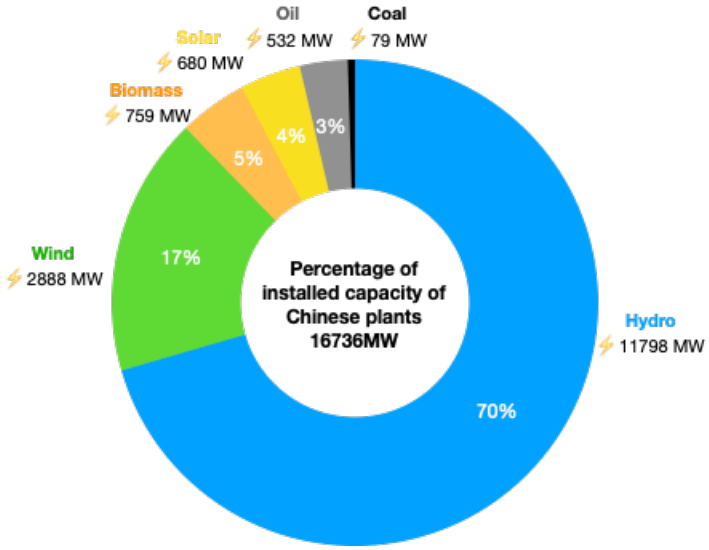
Analyzing the distribution of investments in terms of source of energy – therefore, only considering generation –, hydropower received 81 percent of all investments. Most of the deals happened in 2015 and 2017, because of, as explained above, CTG's and State Grid's acquisitions of dams and of CPFL respectively, which has numerous hydro plants under its portfolio. Wind power came in a distant second place, with 12 percent of the total, mainly due to projects from CPFL Renovaveis, CGN and EDPR, which are concentrated in the last few years of the period. CGN only arrived in Brazil in 2019. Coal power received 4 percent of the funds, and solar 3 percent. Oil share was very small, and biomass was zero, since COFCO's acquisitions of Noble's plants had no numbers disclosed.

Chinese companies' preference for hydro plants goes in tandem with the structure of Brazil's electricity matrix, 63 percent of which is based on hydraulics (Aneel, 2020). The recent upsurge in investments in wind power reflects somehow the incentives that this kind of projects received in the last few years from the national and local authorities, which have been fostering new projects and biddings. Due to this stimulus, wind power accounts for 9 percent of the total generation (Aneel, 2020). Although also seen as a priority to the government, solar generation did not experience the same pace of expansion. However, the source has been gaining growing space in Aneel's bids.

Power generation

As a natural consequence of the roughly US$29.7 billion invested in Brazil over the years, Chinese electric power firms progressively expanded the percentage of Brazil's electricity installed capacity under their control. In the end of 2019, these companies owned or partially owned 304 power plants, which totaled 16,736 MW. This is close to 10 percent of the national system, which ended 2019 with 170 GW (ONS, 2020).

Figure 9: Chinese companies' installed capacity per source of energy (GW)



Source: Aneel.

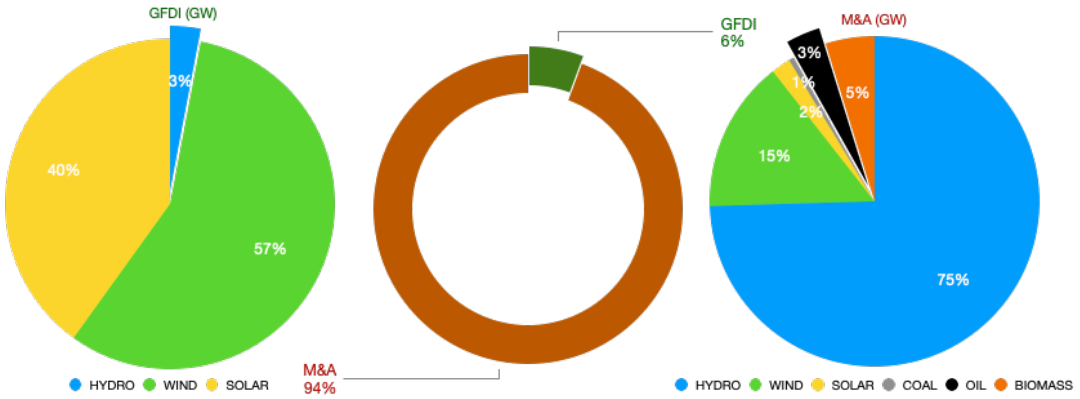
In terms of the technology mix, 70 percent of Chinese electricity capacity in 2019 was in hydropower (11798 MW). Wind power took up 17 percent (2888 MW), and biomass, solar, oil, and coal comprised 5 percent (759 MW), 4 percent (680 MW), 3 percent (532 MW) and 1 percent (79 MW), respectively. This distribution reflects the pattern of Chinese FDI in Brazil, which were concentrated in hydro and wind plants, as shown in the section above.

Putting Brazil's entire electricity matrix and the Chinese power generation assets in Brazil in perspective, there are resemblances and differences. Primarily, the latter is similar to the overall installed capacity, 64.9 percent of which was based on hydropower in 2019. Additionally, both matrixes were based on renewable energy, with the distinction that the Chinese one (97 percent) is even cleaner than the national structure (83.4 percent) (EPE, 2020). Distinctions are: 25 percent of the national capacity came from thermoelectric plants, whereas the Chinese percentage in Brazil was 9 percent; Chinese actors invested more in solar and wind (21 percent), whilst Brazil's capacity was roughly 10 percent; there were no Chinese investments in nuclear power, which was 2.6 percent of the national matrix (EPE, 2020).

Interestingly, Chinese electricity assets in Brazil diverged from its own national matrix, of which 27 percent is based on renewables in 2019 (BP, 2020). Moreover, comparing China's investments in Brazil with those in other nations, new differences emerge. Most of Chinese overseas installed capacity is on coal power (42 percent), followed by hydro (26 percent), gas (15 percent), wind (6 percent), nuclear (5 percent), solar (4 percent) and oil (2 percent). Biomass and geothermal figures are minimal (Gallagher, et al., 2019). Therefore, 36 percent of the country's foreign generation came from renewables, 9 percent more than its national installed capacity. The case of Brazil illustrates that Chinese players focused their energy investments where the host country has a natural advantage or an abundance of resources.

Of the total Chinese installed capacity in Brazil, the absolute majority was acquired through M&A. Interestingly, analyzing separately each type of investment, it becomes clear that while brownfield investments targeted all sources of electricity, with a prominence on hydropower and secondly wind, GFDI almost exclusively went to wind and solar generation. A possible explanation is that both

Figure 10: Chinese installed capacity in Brazil per technology (GW) and mode of entry



Source: Aneel.

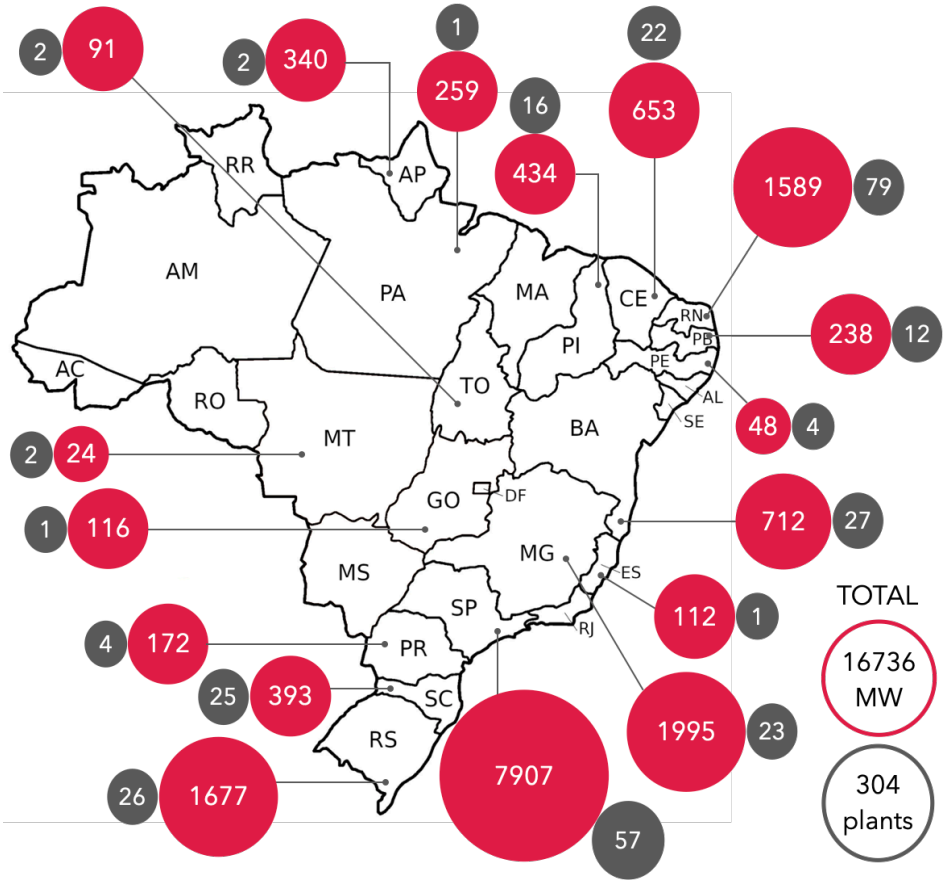
industries have received a strong governmental push, with fiscal incentives and regular public auctions over the last few years, aiming at making full use of the country's potential. CPFL Renovaveis, Canadian Solar, EDP EDPR, Atlantic Energias Renovaveis (owned by CGN) and Celesc (controlled by EDP Brasil) were frequent participants in these bids. It is also true that most of these new projects on solar and wind are relatively recent. For instance, the first public auction on solar generation was only held on October, 2014, and these auctioned farms entered into operation in the end of 2017.

Focusing on the spatial distribution, the Chinese owned 304 power plants were dispersed in 17 states and were present in all five regions of the country. The Northeast concentrated the majority of plants (160), and the Southeast, the highest capacity (10 GW). The difference is explained by the fact that, due to local favorable conditions, the Northeastern states concentrate the bulk of the country's wind and solar farms, whose capacity per unit is much lower than the usually big-scale hydro dams. The 160 Northeastern plants comprised 3.7 GW in total. In contrast, the Southeast's 10 GW is scattered among 81 units. Individually speaking, the Northeastern state of Rio Grande do Norte (RN) had the top number of plants (79), and the Southeastern Sao Paulo (SP), the biggest generation capacity (7.9 GW). The Southern states ranked third, with 55 units and 2.2 GW, followed by the North with 5 dams and 0.7 GW, and the Center-West with 3 dams and 1.4 GW. It is worthy to note that there are no generation assets in Rio de Janeiro, which has the sixth biggest capacity of the country (EPE, 2020) and 10 percent of the national GDP (IBGE, 2020).

If one considers the short time since Chinese firms arrived in the generation sector, the fast pace of their expansion is remarkable. After two years of relatively low increase of installed capacity, mainly due to the fact that CTG was indirectly investing in Brazil through EDP, numbers grew exponentially after 2015, reaching 6.7 GW at the end of the year. 2017 was an important turning point, because State Grid bought CPFL, which possesses several thousands of MW in its portfolio. Total Chinese-installed capacity jumped to 14.7 GW and has kept rising until 2019 with 16.7 GW.

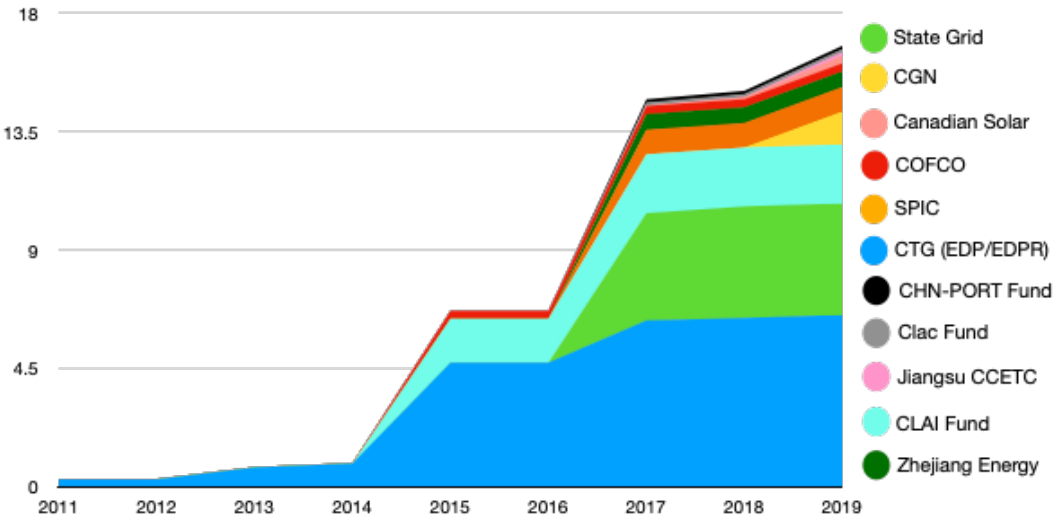
The first Chinese firm to enter Brazil's generation sector was CTG, with the purchase of Energias de Portugal (EDP) in 2011, guaranteeing therefore an indirect participation in EDP Brasil and EDPR, which were already well-established in the Brazilian energy market, with stakes in transmission and distribution as well. Over the following years, CTG has consistently invested in other projects in the country. CLAI Fund and COFCO followed suit in 2015 and were joined by State Grid, SPIC, Zhejiang Energy, CLAC Fund, China-Portuguese Speaking Countries Fund (CPSC Fund) and Canadian Solar in 2017. Jiangsu CCETEC and CGN finally arrived in Brazil in 2019.

Figure 11: Geographical distribution of plants and installed capacity



Source: Aneel.

Figure 12: Yearly installed capacity per company (GW)



Source: Aneel.

Figure 13: Installed capacity per source and number of plants[10]

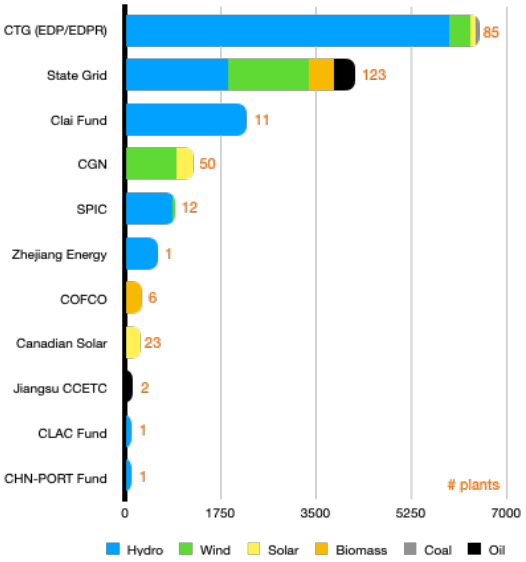


Figure 14: Numbers of generation plants per state

Source: Aneel.

On the company level, CTG is the one that accumulated more generation capacity over the years (6.5 GW) and is Brazil's second biggest electricity generator. It is established in 12 states, but has the majority of its stakes in Sao Paulo (16), Santa Catarina (18) and Rio Grande do Norte (37). Its energy technology matrix is also diversified. It is mainly based on hydraulics notwithstanding, the company invested also in wind – alone and through EDPR as well –, solar and coal power.

State Grid had 4.3 GW scattered among 123 units in 10 states. All this capacity belongs to CPFL. This is the third biggest private agent in Brazil's generation sector – and the ninth in total (Aneel, 2020). The reason for having more units than CTG, but less capacity, is because CPFL has a more diversified portfolio. CPFL's own hydro power capacity did not reach half of the total, with the rest divided among wind, biomass, oil and very little solar power. The majority of CPFL's plants are in Sao Paulo (35) and Rio Grande do Norte (37).

The Huikai Clean Energy, which is controlled by the CLAI Fund, had a total of 2.2 GW in 11 hydropower dams in Sao Paulo (9), Parana (1) and Mato Grosso do Sul (1), all of them in partnership with CTG. Other Chinese investment funds active in Brazil are the CLAC Fund (120 MW) and the CPSF (120 MW). Like Zhejiang Energy (599 MW), they have joined SPIC to acquire the Sao Simao dam (MG), their sole possession in Brazil. By contrast, SPIC had other 11 units and 930 MW in Paraiba.

Distinctively, CGN has no hydroelectric dams and has invested only in wind and solar generation. It owned 50 plants that totaled 1.3 GW of capacity in the states of Rio Grande do Sul (12), Bahia (20), Piaui (16) and Rio Grande do Norte (2). COFCO, Canadian Solar and Jiangsu CCTEC are other examples of no assets in hydro. COFCO had 6 biomass facilities (303 MW) in Sao Paulo, Canadian Solar had 23 solar farms (288 MW) in Minas Gerais (10), Pernambuco (4) and Ceara (9), and CCTEC, 2 oil units in Bahia of 136 MW in total.

Canadian Solar is the only non-SOE that had generation assets in Brazil. Consequently, 98 percent of the Chinese projects in the country belongs to firms indirectly managed by central and provincial branches of the State-owned Assets Supervision and Administration Commission (SASAC).

[10] The number of plants refers to the units where each company have stakes; in some plants, more than one Chinese company have shares.

Figure 15: Geographical distribution of Chinese installed capacity per source (MW)

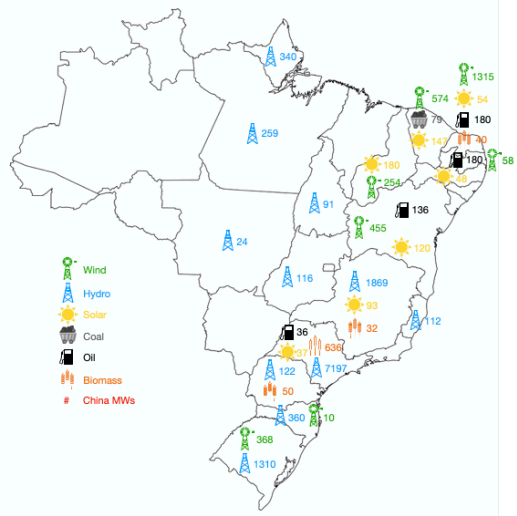
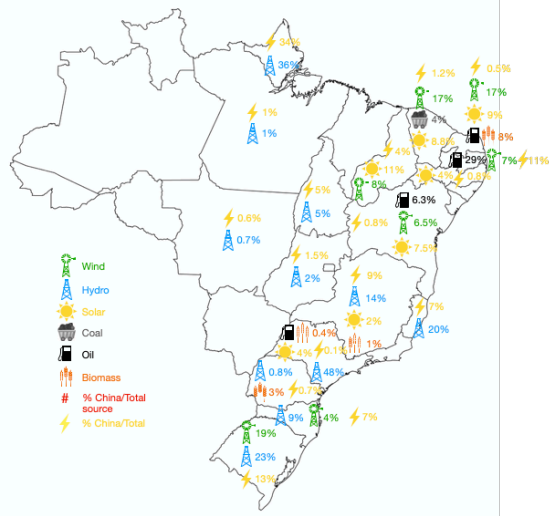


Figure 16: Percentage of Chinese installed capacity per source and state[11] [12] [13]



Source: Aneel.

Analyzing the geographical distribution of installed capacity in terms of technology mix, there are some interesting findings. Firstly, hydro power is present in all regions, except the Northeast, where the favorable natural endowment made wind and solar projects dominate. Besides the Northeast, there are some wind and solar plants in the South (Rio Grande do Sul and Santa Catarina) and Southeast (Sao Paulo and Minas Gerais), although with smaller numbers. Biomass was mostly concentrated in Sao Paulo, with one plant in the states of Parana, Minas Gerais and Rio Grande do Norte, each. Oil-fueled power plants were mainly in the Northeast, with one facility at Sao Paulo. Lastly, coal was only present in Ceara, in a small-scale project. Individually, Sao Paulo was the state that not only had the biggest installed capacity overall, but led as well in hydropower and biomass. Rio Grande do Norte had the majority of wind farms, and Ceara, the most of solar generation.

Calculating the percentage of how much Chinese players had per source of electricity in each state (Aneel, 2020), other remarkable results are found. Firstly, in terms of total electricity capacity, China's participation varied considerably. Some states' electricity production had high contribution from Chinese companies, such as Amapa (34 percent), Rio Grande do Sul (13 percent) and Paraiba (11 percent). However, in general, Chinese shares was small.

Secondly, in an electricity source analysis, the situation is different. For instance, despite the fact that Sao Paulo concentrated most of Chinese stakes, China's participation in this state's total installed capacity was minimal (0.1 percent). However, 48 percent of the state's hydro generation was in the hands of Chinese actors. Different to other places that rely more on one source of energy, Sao Paulo has a diversified and balanced technology mix. In Amapa, Rio Grande do Sul and Espirito Santo, 36 percent, 23 percent and 20 percent of the hydropower capacity was administered by

[11] Aneel does not provide separate data about thermoelectrical energy sources, such as coal, oil and biomass in the state level. Therefore, the used numbers for calculation were those of the generation capacity of thermoelectrical dams in each state.

[12] The data chosen about state's total generation capacity encompasses those related to operational, under construction and construction not initiated, because some Chinese projects are still not operational.

[13] Since Aneel does not provide historical data of each state installed capacity per technology, the numbers used are from May 2020.

Chinese companies, respectively. In wind power generation, Chinese firms possessed 19 percent of Rio Grande do Sul's capacity and 17 percent of Ceara and Rio Grande do Norte. In solar power, they have 13 percent in Rio Grande do Sul and 11 percent in Piaui, to name a few.

Having identified and described the Chinese power assets in Brazil and analyzed their exponential growth over a relatively short period of time, it is also important to put them in a broader picture, so as to better understand the scale and the impacts of this phenomenon. There are two ways to do it: to compare Chinese generation investments in Brazil and in other countries, and to parallel the performance of Chinese players with other foreign counterparts over time.

Positioning Chinese investments in Brazil from a global perspective, it is easier to understand the role and the importance of the country in China's global energy investments. According to data from the Global Development Policy Center, until 2018, at least 63 Chinese energy firms have full or partial asset ownership in up to 186.5 GW of overseas capacity, distributed through 777 plants. Asia by far concentrates most of the Chinese assets, with Latin America coming in a distant second place. Individually, Brazil was the main target, followed by Pakistan, Indonesia and Vietnam. Out of the ten biggest Chinese companies abroad in terms of installed capacity, only three of them had assets in Brazil, namely CGN (ranking 1st), CTG (2nd) and State Grid (7th). Some Chinese giant energy firms, such as China Huaneng Corporation (3rd), CLP Holdings (4th) and China Huadian Corporation (6th), had no projects in Brazil (Gallagher, et al., 2019).

Until the end of 2018, CGN accumulated a total of 19,740 MW, whereas CTG 16,718 MW, SPIC 9,178 MW, State Grid 7,409 MW, and Canadian Solar 3,167 MW. Comparing with their assets in Brazil until that year, the South American country represented roughly 6 percent[14], 39 percent, 10 percent, 57 percent and 9 percent of their overseas possessions respectively.

In addition, to have a better understanding and a clearer picture of the size and penetration of Chinese electric investments in Brazil's generation sector, it is important to put them in perspective and compare with other foreign players' performance in the country and analyze the resulting changes in the segment's ownership structure over time. New findings show that the Chinese were not alone in this expansion process; other countries' corporations also took advantage of increasing sectoral opportunities. However, most of these companies were already present there and, thus, only enlarged their activities in organic and inorganic ways. As a distinct feature, Chinese were essentially newcomers joining the already established club.

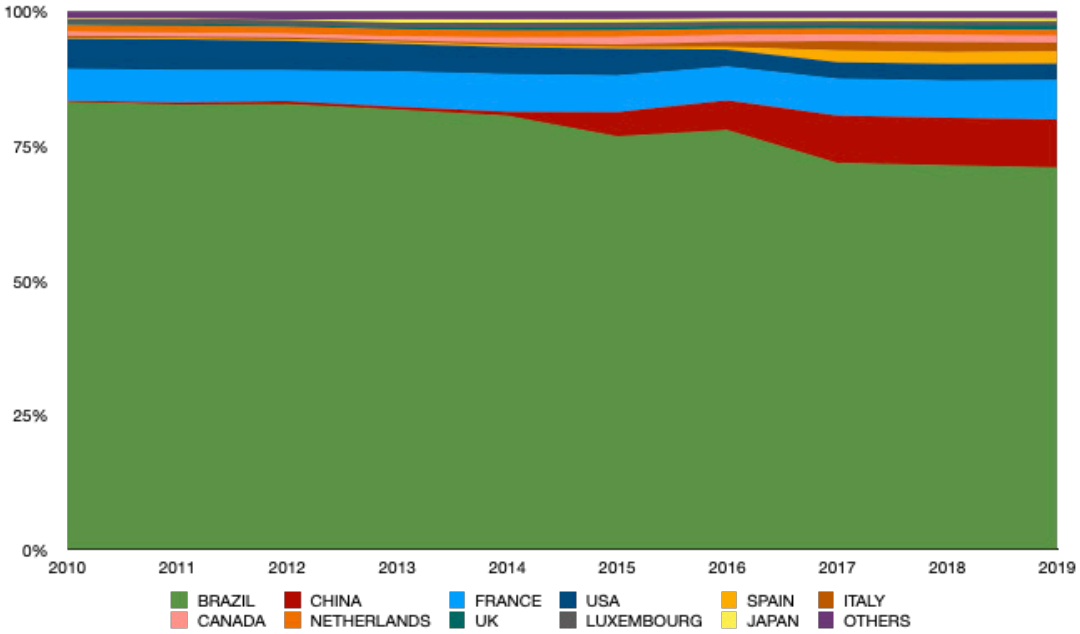
Mapping the changes in the ownership structure of Brazil's 8,728 power plants in operation in 2019 and tracing back these modifications until 2010, one may see a process of continuous internationalization and diversification of the local generation sector[15]. Over the years, new foreign players from different nationalities have begun to buy assets or to start new businesses. Their share of the total installed capacity has progressively increased over the years at the expense of national actors, who were not necessarily disinvesting or reducing its activities, but sometimes growing in a slower pace. At the end of 2019, there were companies from 31 countries active in Brazil[16].

[14] Since CGN's first investment in Brazil was in 2019, for the sake of comparison, we are using these numbers to compare with the company`s total assets through 2018.

[15] Some authors trace back this internationalization process' origins further in time and describe it as policy choice by Brazilian decision-makers. In 2011, a widespread blackout exposed the electricity system's vulnerabilities, such as the hydropower-dependent system and poor interconnectedness between regional power grids. As a response, the government has pushed forward reforms to expand and improve power generation, transmission, and distribution and to attract foreign firms to these sectors, so as to solve these problems and match the growing electricity demand in the coming years (Cote, 2014 p. 18).

[16] The nationality is defined according to the address registered at Aneel. Countries are Argentina, Australia, Austria, Bahamas, Bangladesh, Belgium, Canada, Cayman Islands, Chile, China, Cyprus, Denmark, Finland, France, Germany, India, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Peru, Portugal, South Africa, South Korea, Spain, Switzerland, UK, USA.

Figure 17: Nationalities of generation concessionaires (MW)



Source: Aneel.

Brazilian concessionaires started the period of analysis with 83 percent of the generation segment, followed by French and North-American, with around 6 percent each. Over time, this situation has changed, particularly from 2014 on, when Chinese capital started to flow in great quantities. The entrance of Chinese actors has caused the biggest changes in ownership structure, progressively occupying the space from local firms and ending 2019 in the second place. US shares also decreased over time, but not in the same speed of the Brazil's one. French companies have pretty much kept their annual percentage, but in 2017 lost their leading position among foreigners to China. Spanish, Italian and Canadian corporations' capacity have grown steadily year by year, especially the former ones, at the expense of Dutch and Luxembourgian. After all these changes, 2019 ended with Brazilian players with 71 percent of the generation segment, followed by the Chinese with nearly 10 percent, French with 7 percent and so on.

The same phenomenon of internationalization of the nation's generation sector was also described by a report published by Getulio Vargas Foundation in 2018, which, however, does not distinguish the nationalities of international firms. Making use of a different methodology, drawing data from M&A transactions in the electric sector and from the results of Aneel's auctions between January 2016 and June 2018, the study concluded that there was a high degree of participation of foreign actors in Brazil's electric-related M&A and biddings.

The majority of the M&A in Brazil's power segment were headed by foreign firms, almost 73 percent of the deals in Real terms (R$). Of this number, 42.5 percent came from private investors, and 30.4 percent from state-owned. Among the public biddings, less than 16 percent of the projects auctioned were taken by domestic actors – all private, no public companies –, whereas 84.1 percent of them ended in the hands of multinational corporations, including government-run ones – 10.5 percent. As a result of these transactions, international companies possessed roughly 21 percent of country's installed capacity (Oliveira, et al., 2018).

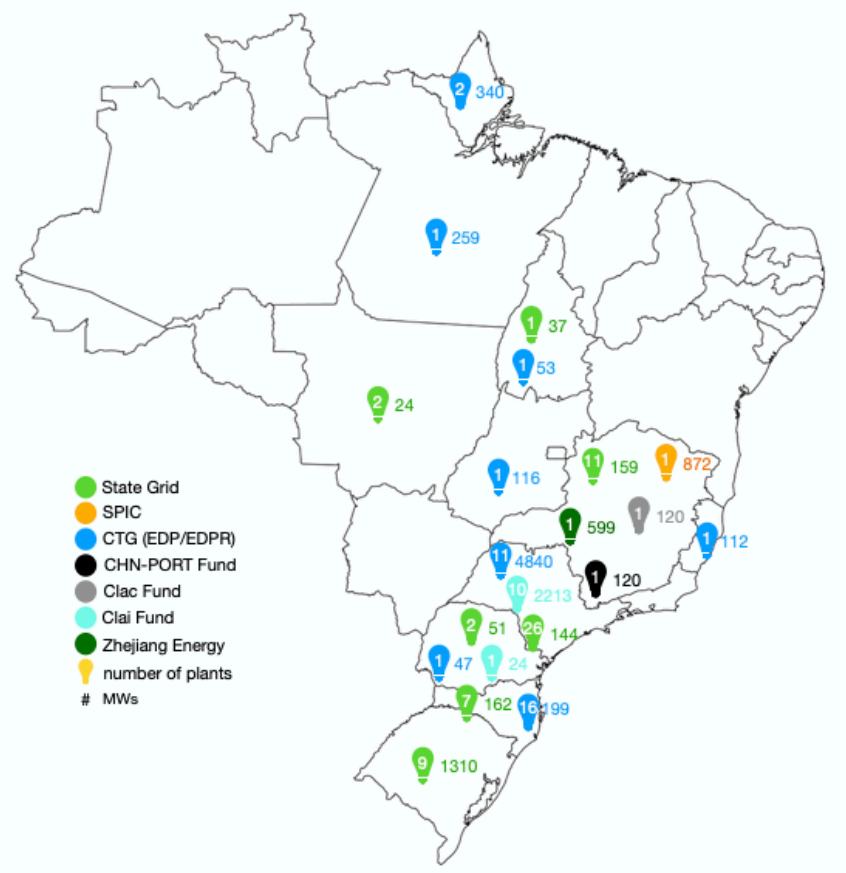
CHINESE INVESTMENTS IN BRAZIL'S HYDROPOWER SECTOR

China's hydropower installed capacity in Brazil is 11.8 GW, or 70 percent of Chinese firms' total, and is divided in 93 dams, located in 11 states. Only the Northeast region has no Chinese administered hydroelectric dams. Comparing to the country's total installed hydropower capacity – operational, under construction and construction not started –, which ended 2019 with 111 GW (Aneel, 2020), Chinese firms had almost 11 percent of the national sector[17]. Seven companies have been investing in the sector, namely CTG (including EDP Brasil), State Grid (which operates through CPFL), SPIC, Zhejiang Energy International, CLAI Fund, CLAC Fund and CPSC Fund.

CTG is the one with bigger installed capacity (5965 MW), in 34 dams. 16 were in Santa Catarina, and most of them (15) belonged to Celesc. In contrast, Sao Paulo had the majority of the generation power (4840 MW).

As mentioned above, CTG arrived in Brazil in 2011, when it became the single biggest investor at EDP Energias de Portugal. Apart from EDP, CTG bought 50 percent of the Santo Antonio do Jari (AP) and Cachoeira Caldeirao (AP) dams from EDP Brasil for US$179 million in 2013. In the following year, CTG acquired 33 percent of the Sao Manoel (PA) dam also from EDP for US$348 million. In 2015,

Figure 18: Geographical distribution of hydro installed capacity per company (MW)



Source: Aneel.

[17] Considering only operational dams, the percentage is also 11 percent. The reason is that the capacity that will be brought by incoming dams is small, comparing to the total in the end of 2019.

CTG bought from Triunfo the controlling stakes of Rio Verde Energia S.A., Rio Canoas Energia S.A. e Triunfo Negocios de Energia, for US$486 million. The first of these is responsible for the Salto dam (GO), and the second, for the Garibaldi dam (SC). In the end of 2015, CTG won the bid for the Jupia (SP) and Ilha Solteira dams (SP) and paid US$3.7 billion, which was the company's then-biggest overseas acquisition. This deal could be considered a milestone in the firm's expansion in Brazil, because both were large dams, Ilha Solteira alone is the nation's 6th largest. As a result, CTG became the second major electric generator in Brazil, behind the state-owned Eletrobras (Aneel, 2020). In 2016, CTG purchased all Duke Energy's assets in Brazil for US$1.2 billion, eight dams in total. In 2018 and 2019, EDP successively bought shares at Celesc, a former state-owned electric company with several dams under its portfolio in Santa Catarina, and became its largest stakeholder.

After CTG, the CLAI Fund was the one with more installed capacity (2236 MW). Operating under the name of Huikai Clean Energy, it had participation in 11 dams, one in Parana and ten in Sao Paulo, and all of them in partnership with CTG. For the ownership of 33 percent of Duke's assets in Brazil, it paid US$323 million in 2017.

State Grid had 1887 MW in Brazil, all of them part of CPFL's portfolio. This company had a total of 58 dams, in seven states. The majority are in Sao Paulo (26), mostly small size (known as PCH). Yet, in terms of installed capacity, Rio Grande do Sul had more MW. State Grid has been active in the country since 2010, but only in 2017, when it paid US$12.2 billion for CPFL, the Chinese firm entered in the generation sector. In 2018, it paid another US$1.1 billion for the renewable energy arm of CPFL: CPFL Renovaveis.

SPIC, Zhejiang Energy, CLAC Fund, and CPSC Fund all started to invest in Brazil's power generation in 2017, when their consortium won the bid for the Sao Simao dam (MG), a transaction that involved almost US$2.3 billion. SPIC has 51 percent of the barrage, whilst Zhejiang Energy has 35 percent, and the other two, 7 percent each.

Long before this transaction, SPIC has been trying to enter in Brazil. In 2013, it opened an office in the city of Rio de Janeiro, so as to start looking for investment opportunities (Schutte, et al., 2017 p. 107). In 2017, SPIC made a proposal to buy the Santo Antonio dam, the fifth biggest in Brazil, and gave up latter (Bautzer, 2017).

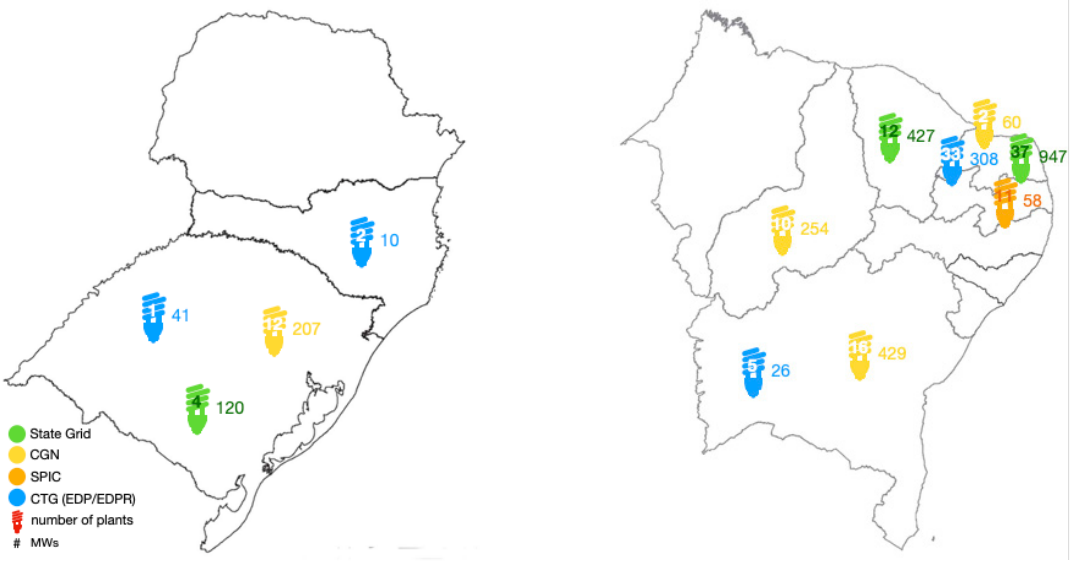
CHINESE INVESTMENTS IN BRAZIL'S WIND POWER SECTOR

Chinese wind power capacity in Brazil is 2888 MW, or 17 percent of their total installed capacity. Comparing with the national total of 24854 MW in plants that are in operation, under construction or construction not started (Aneel, 2020), it is roughly 12 percent of the country's wind generation capacity[18]. There are wind farms in the Northeast and the South of the country, in seven different states. Four companies have assets in the sector, namely State Grid, CGN, CTG and SPIC.

Among Chinese firms in Brazil, State Grid has the most MW installed (1494 MW) and the most individual wind farms (51), mostly in the Northeastern Rio Grande do Norte and Ceara, but there are some in the Southern Rio Grande do Sul. As in hydropower investments, everything directly belongs to CPFL, more specifically CPFL Renovaveis. The great majority of the plants were developed before State Grid's acquisition, but CPFL's expansion continued after, especially through participation in

[18] Considering only operational wind farms, the percentage goes to 19 percent. The reason for this difference is because the Brazilian wind sector is undergoing a fast expansion over the last few years. The projects that will become operational in the following years will expand the installed capacity in 2019 by approximately 60 percent.

Figure 19: Geographical distribution of wind installed capacity per company (MW; South and Northeast)



Source: Aneel.

Aneel's bids. After years of heavy investments in the sector, CPFL became the main single wind power generator in Brazil (Aneel, 2020).

CGN comes after State Grid in wind power, with roughly 950 MW, in 40 plants. The company is present in four states, namely Bahia, Piaui, Rio Grande do Norte and Rio Grande do Sul. As explained above, the firm arrived in Brazil in January 2019 through the acquisition of three farms from Italian Enel, for US$779 millions (Enel, 2019). Less than one month later, another transaction: CGN acquired the Brazilian wind power company Atlantic Energias Renovaveis from Actis Capital, for almost US$1.1 billion (Castano, 2018). After becoming part of the Chinese company, Atlantic kept participating in Aneel's auctions and won bids for other wind facilities.

CTG has 385 MW in 41 projects, either directly or through EDPR. The company is present in four states, although the absolute majority is in Rio Grande do Norte. EDPR started investing in Brazil's wind sector in 2013 through Aneel's auctions. In May 2015, CTG bought 49 percent in 11 farms from EDPR, for US$155 million. Over the following years, EDPR won several new projects in Aneel's bids.

Lastly, SPIC had 58 MW in 11 farms, in Paraiba. All these assets were purchased from Pacific Hydro Brasil, in 2017. The Chinese firm has an office in Rio Grande do Norte for prospecting and developing new projects in the Northeast, where it plans to invest US$959 millions in the following years (TribunadoNorte, 2019).

The Chinese wind turbine developer Xinjiang Goldwind Science & Technology has been trying to enter in Brazil's generation sector over the last years. The company has CTG as one of its shareholders (Husar, et al., 2013 p. 26). In 2017, Goldwind was negotiating the purchase of 70 percent of the Argentinian Energimp's wind farms (Reuters, 2017).

CHINESE INVESTMENTS IN BRAZIL'S SOLAR POWER SECTOR

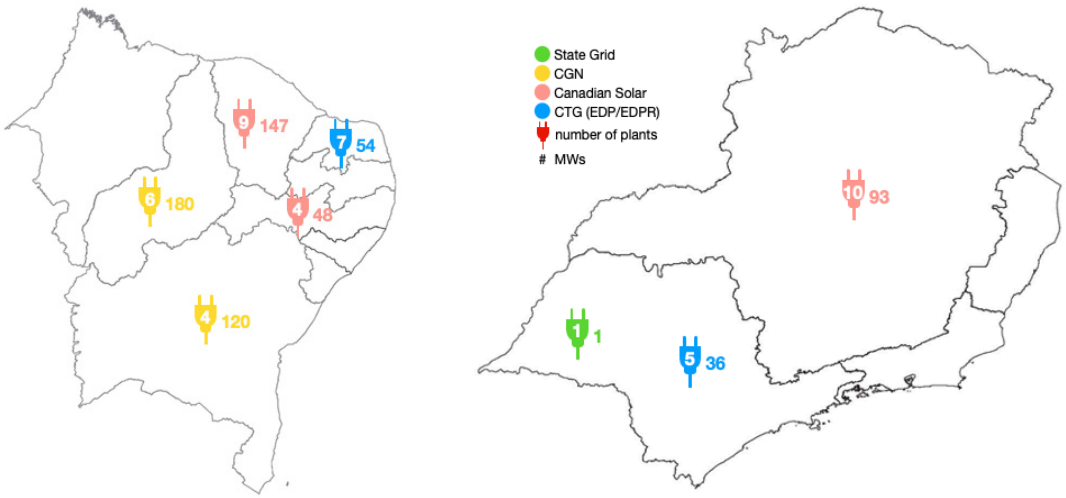
Chinese companies' solar generation capacity was 680 MW in the end of 2019, including projects to be implemented in the near future. With the total of 12929 MW that are in operation, under construction or construction not started in Brazil (Aneel, 2020), it is roughly 5 percent of the country's total solar power[19]. Solar farms are located mostly in the Northeast, but there are some projects in the Southeastern Sao Paulo and Minas Gerais. Canadian Solar, CGN, CTG and State Grid were the Chinese firms that generate electricity from solar panels. Interestingly, China Datang Corp, one of the major photovoltaic generators in the world, had no investments in Brazil during the period of this study (Sebrae, 2017).

Canadian Solar is the company that invested the most in Brazil. In the end of 2019, it had 23 solar farms of 288 MW total, mostly under construction and located in Minas Gerais, Ceara and Pernambuco. It has been actively participating in Aneel's auctions since 2014. However, over the years, the companies have done some disinvestments. In 2014 and 2015, it won sole concessions to build 11 solar farms in Minas Gerais, but afterward sold them to the French EDF. A great part of the remaining projects was also partially sold to a partner company from Qatar, Nebras, the following years. Canadian Solar kept an 80 percent share in these farms.

CGN has 10 farms with 300 MW in Bahia and Piaui. They are all part of the three solar parks that CGN bought in 2019 from Enel Green Power, the biggest wind power producer in the country. The acquisition of these parks led the company to become one of the major solar players in Brazil. For instance, just the purchases of Bom Jesus da Lapa, Nova Lapa and Nova Olinda – which is divided in B, C and Norte – occupy respectively the third until the seventh places in terms of installed capacity (Aneel, 2020).

CTG had 12 plants with 90 MW in total. There all belong to EDPR and are located in Sao Paulo and Rio Grande do Norte. Lastly, State Grid/CPFL Renovaveis had only a small-scale project in Sao Paulo.

Figure 20: Geographical distribution of solar installed capacity per company (MW; Northeast and Southeast)



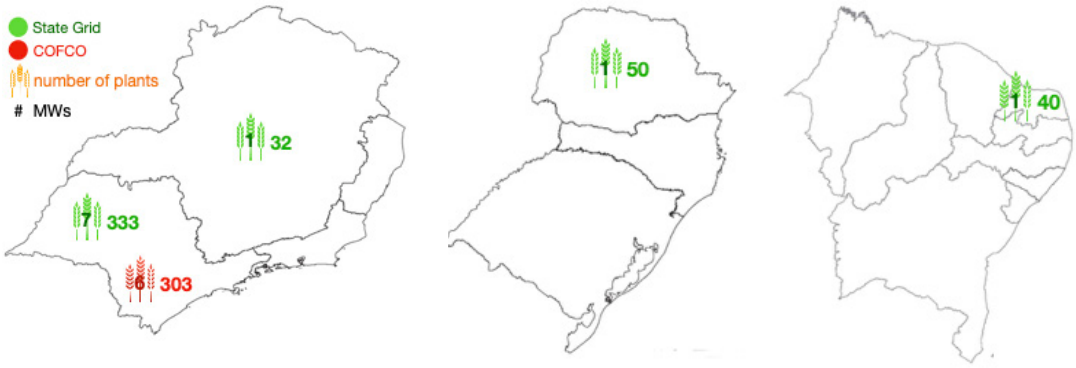
Source: Aneel.

[19] Considering only operational wind farms, the percentage jumps to 23 percent. The reason for this difference is because the Brazilian solar sector, like the wind one, is under fast expansion. The solar farms that will become operational in the following years will expand the installed capacity in 2019 more than three times.

CHINESE INVESTMENTS IN BRAZIL'S BIOMASS POWER SECTOR

Chinese corporations have 16 biomass plants whose installed capacity is 759 MW as of 2019. Most of them were located in Sao Paulo, with other single projects in Minas Gerais, Parana and Rio Grande do Norte. Considering that Brazil's total biomass generation capacity in that year was 15234 MW[20] (Aneel, 2020), the Chinese share was close to 5 percent of the whole. Only State Grid and COFCO have investments in this sector.

Figure 21: Geographical distribution of biomass installed capacity per company (MW; Southeast, South and Northeast)



Source: Aneel.

CPFL Renovaveis has 10 plants with a total of 455 MW, most of them in Sao Paulo (7). COFCO, in contrast, have six facilities in Sao Paulo. They were inherited from Noble in 2015.

Back in 2018, China Jinjiang Environment announced the purchase of controlling stakes in the Brazilian company Foxx URE-BA Ambiental, which would build and operate a waste-fired power plant in the city of Barueri. Nonetheless, the transaction ended not happening (Jinjiang, 2018).

CHINESE INVESTMENTS IN BRAZIL'S NON-RENEWABLES SOURCES

As argued above, Chinese firms concentrated their investments in sources of energy in which Brazil has a natural advantage or abundance of resources. Therefore, it is not surprising that Chinese assets in non-renewable energy facilities in the country – 611 MW – are a small percentage of the total, only 4 percent. There are six plants, using oil and coal to generate electricity. As of end-2019, there are no projects with nuclear energy. State Grid, CTG and Jiangsu Communication Clean Energy Technology (CCETC) were the owners.

CPFL has one oil-based thermoelectric plant in the states of Sao Paulo, Paraiba and Rio Grande do Norte. CCETC, in contrast, has two in Bahia, which are under construction as of end-2019. At the beginning of this year, CCETC agreed to pay US$107 million to buy 45 percent of the Pecem II and 50 percent of the Camacari Muricy II plants from Petrobras and the investment fund MDC (Greenhill, 2019).

[20] Aneel does not distinguish the thermoelectric plants under construction and construction not started per source – biomass, oil, coal –, so in this part, the comparison is only made with biomass facilities in operation.

Brazil represents only a small fraction of China's overseas coal-based generation investments, which amounted to 79500 MW in 107 plants, or 42 percent of the total in 2018 (Gallagher, et al., 2019). The single coal-based Chinese asset in Brazil is Porto de Pecem I, in Ceara, and is owned by EDP.

As mentioned, China has not developed or bought any nuclear energy projects in Brazil, as of 2019. The reason is that the two nuclear plants in the country – Angra I and Angra II – belong to the state-owned Eletronuclear. Notwithstanding this, Chinese nuclear firms have been consistently trying to enter this sector.

In 2013, the state-owned State Nuclear Power Technology Corporation (SNPTC) opened an office in Rio de Janeiro, aiming at prospecting local projects and partners. At that time, Brazil was considering to conclude Angra III plant and to build eight new nuclear facilities, a plant that came to halt, among other reasons, due to the country's economic recession (Cuperstein, 2014 p. 16).

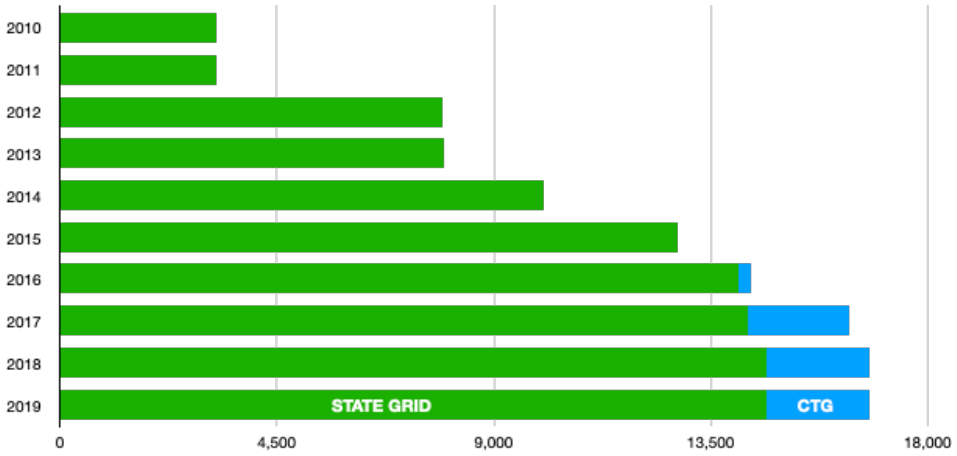
In October 2019, Eletronuclear unveiled new plans to complete the long-delayed Angra III by partnering with foreign companies. China's National Nuclear Corporation (CNNC) and SPIC, among other French, Korean and Russian firms, were interested (Boyle, 2019).

CNNC is another Chinese SOE that has been trying to invest in Brazil's nuclear sector. It has already signed three memoranda of understanding with Eletronuclear in nuclear cooperation in 2015, 2016 and 2017, during high-level political visits (Aben, 2017).

Transmission

The history of Chinese investments in Brazil's transmission sector is entangled with State Grid's individual expansion and experience there. The largest electric company in the world accounts for 95 percent of the US$6.3 billion that have been invested there as of 2019. As a natural consequence, 87 percent of the 16,776 km of Chinese-owned transmission lines belong to it[21]. Despite the fact that it is the major Chinese investor, State Grid is not alone. CTG, always through EDP and Celesc,

Figure 22: Length of Chinese transmission lines per company (km)



Source: Aneel.

[21] In the total of Chinese-owned lines, projects from Celesc and Zhejiang Insigma are not included, since the participation of CTG and Zhejiang in those are minimal.

and Zhejiang Insigma United Engineering are other Chinese active players. Their assets altogether account for almost 12 percent of the total length of lines. State Grid alone represents more than 10 percent of the whole (ONS, 2020).

State Grid is unquestionably the biggest Chinese transmission company in Brazil, but it was not the first to arrive. In early December 2010, Zhejiang Insigma, in partnership with Procable and CEEE-GT, won a bid to build and operate transmission lines and substations in Rio Grande do Sul. That is the only transaction of the firm in the period of study. In the winning consortium, it had 40 percent of the new enterprise Transmissora de Energia Sul Brasil S.A. (TESB) (Aneel, 2020), a percentage that diminished progressively over time and ended at 6.6 percent in 2019 (Aneel, 2020).

One week later, State Grid completed a deal announced in May of the same year: the purchase of seven concessions from the Spanish Plena Transmissora, for approximately US$1.13 billion (OGlobo, 2010). In December, it inaugurated a whole building in the city of Rio de Janeiro, an investment estimated in US$156 million (Becard, et al., 2014 p. 148). From then on, in a mix of new projects and acquisitions of companies or specific transmission lines, State Grid has consistently expanded its assets.

In 2011, in collaboration with the government-run Furnas, State Grid won its first bid in Brazil, for the construction of substations in Goias (Aneel, 2011). In 2012, it partnered with the state-owned Copel in three greenfield undertakings, which involved several lines crossing the Center-West, Southeast and Northeast (Aneel, 2012). In the end of the year, the company concluded the purchase of 14 lines from the Spanish group Actividades de Construccion y Servicios (ACS), for US$945 million, a transaction that involved the acceptance of the corporation's debts (Zhu, et al., 2012).

New M&A happened in 2015, once again with a Spanish firm involved. Cobra Instalaciones y Servicios sold the Montes Claros' lines for around US$39 million in July 2015, the same month that a group of Portuguese companies merchandised the concessionaire Atlantico (Aneel, 2015). In the following years, State Grid has kept an active participation in public tenders, either directly or through CPFL, whose transmission lines were incorporated in 2017 as well.

Table 2: State Grid Transmission Lines in Brazil

Date of Deal	Concessionaire	Partners	Estimated Length (Km)	Type of Investments	Disinvesting Company
Dec 2010	Itumbiara Transmissora de Energia	None	817	M&A	Plena Transmissora
Dec 2010	Serra Paracatu Transmissora de Energia	None	246	M&A	Plena Transmissora
Dec 2010	Poços de Caldas Transmissora de Energia	None	308	M&A	Plena Transmissora
Dec 2010	Serra da Mesa Transmissora de Energia	None	681	M&A	Plena Transmissora
Dec 2010	Ribeirao Preto Transmissora de Energia	None	412	M&A	Plena Transmissora
Dec 2010	Expansion Transmissao de Energia Eletrica	None	575	M&A	Plena Transmissora

Table 2: State Grid Transmission Lines in Brazil (continued)

Date of Deal	Concessionaire	Partners	Estimated Length (Km)	Type of Investments	Disinvesting Company
Dec 2010	Expansion Transmissao Itumbiara Marimbondo	None	212	M&A	Plena Transmissora
Dec 2011	Luziania-Niquelandia Transmissora	Furnas (49 percent)	0	New	***
Mar 2012	Matrincha Transmissora de Energia (TP Norte)	Copel (49 percent)	1005	New	***
Mar 2012	Guaraciaba Transmissora de Energia (TP Sul)	Copel (49 percent)	606	New	***
Mar 2012	Paranaiba Transmissora de Energia	Copel (24.5 percent), Furnas (24.5 percent)	967	New	***
May 2012	Catxere Transmissora de Energia	None	606	M&A	ACS
May 2012	Iracema Transmissora de Energia	None	400	M&A	ACS
May 2012	Araraquara Transmissora de Energia	None	30	M&A	ACS
May 2012	Linhas de Transmissão do Itatim	None	547	M&A	ACS
May 2012	Porto Primavera Transmissora de Energia	None	506.1	M&A	ACS
Oct 2013	Marechal Rondon Transmissora de Energia	None	33	New	***
Feb 2014	Belo Monte Transmissora de Energia	Furnas (24.5 percent), Eletronorte (24.5 percent)	2092	New	***
Jul 2015	Atlantico Concessionaria de Transmissao de Energia do Brasil	None	79	M&A	CME, Tecneira
Jul 2015	Linhas de Transmissao de Montes Claros	None	162	M&A	Cobra Instalaciones
Jul 2015	Xingu Rio Transmissora de Energia	None	2518	New	***
Apr 2016	Canarana Transmissora de Energia	None	262	New	***
Apr 2016	Paranaita Ribeiraozinho Transmissora de Energia	None	1005	New	***

Table 2: State Grid Transmission Lines in Brazil (continued)

Date of Deal	Concessionaire	Partners	Estimated Length (Km)	Type of Invest-ments	Disinvesting Company
Jan 2017	Consorcio Planalto Transmissao	None	187.3	M&A	CPFL
Jan 2017	CPFL Transmissao Piracicaba	None	0	M&A	CPFL
Jan 2017	CPFL Transmissao Morro Agudo	None	2	M&A	CPFL
Jun 2018	CPFL Transmissao Maracanau	None	2	New	***
Dec 2018	CPFL Transmissao Sul I	None	320	New	***
Dec 2018	CPFL Transmissao Sul II	None	85	New	***

Source: Aneel.

Undoubtedly, State Grid's two landmarks – not only in its development in Brazil, but also in the recent history of the Brazilian transmission sector – were the two lengthy lines of the Belo Monte dam.

Belo Monte is the nation's second largest hydropower station and the fourth biggest in the world, with more than 11 GW of installed capacity. Its construction was strategically relevant to the country's energy security: it was planned to help alleviate the bottleneck between supply and demand. On the one hand, Brazil's main electricity consumer market is located in the Southern regions, where historically most of the hydropower stations were built and, consequently, the local electricity generation potential was well developed. On the other hand, the country's new frontier for large-scale hydropower projects is in the Amazon basin, a region not densely populated and whose generation potential has not yet been fully realized. Estimates have shown that around 70 percent of untapped hydropower resources were located in the North of the country (Aneel, 2008 p. 57). Belo Monte was designed and planned to help equilibrate this delicate balance, but its location in Para, and therefore far from the South, has created an additional layer of challenge: transmission of electricity over great distances.

State Grid's leading expertise and technical experience in long-distance transmission lines in China have matched with Brazil's necessity of upgrading its national power grid, which had been facing hurdles over the years with a strong demand growth, as the 2009 blackouts have shown (Husar, et al., 2013 p. 12). China has also confronted the challenge of unequal distribution of renewable energy resources and load centers. This difficulty was overcome with the deployment of ultra-high voltage (UHV, 800kV), a technology that allows large loads to be transferred over great distances and with reduced energy loss rates of up to 40 percent (Proenca, et al., 2018 p. 282) (Caramuru, et al., 2019 p. 90). Brazil did not have 800 kV lines, but planned to have as much as 7,000 km by 2022 (Cote, 2014 p. 21) (EPE, 2012 p. 192).

Belo Monte's transmission line project included two phases. Phase I involved the construction of nearly 2,100 km of lines from Xingu (Para) until Estreito (Minas Gerais), crossing four states and 65 municipalities. In total, 3,750 transmission towers were built (BMTE, 2014). Phase II implicated the building of more than 2,500 km of lines from Xingu to Rio de Janeiro, passing through five states

and 81 municipalities. 4,448 transmission towers and 69,000 tons of conductors were needed (Hiratuka, 2018 p. 131). Both lines equally cross three complex ecological biomes: Amazon, Cerrado and Atlantic Forest.

Phase I was auctioned in February 2014. In association with the state-owned Furnas (24.5 percent) and Eletronorte (24.5 percent), State Grid (51 percent) presented the best offer and outbid local and Spanish competitors (Aneel, 2014). As in other bids, the concession involves the responsibility of investing, financing, designing, constructing and operating for an average time-range of thirty years, with a possible extension of the concession period (Cui, et al., 2019 p. 243). Phase II was auctioned in July 2015. This time, State Grid independently bid and once again outbid local and Spanish opponents (Aneel, 2015).

The first line was inaugurated and officially put into commercial operation in December 2017 (G1, 2017), whereas the second one was launched in June 2019 (StateGrid, 2019). Both phases mark the first time that an 800 kV UHV transmission line is invested, designed, constructed and operated in another country by State Grid (Hiratuka, 2018 p. 131). The latter is in fact the world's longest 800 kV UHV transmission line (Caramuru, et al., 2019 p. 90). Because of the successful launch of both phases and the complementary between both countries in the transmission sector, the cooperation was highly praised by both sides as win-win (Hiratuka, 2018 p. 131) (Cui, et al., 2019 p. 236).

Table 3: EDP Transmission Lines in Brazil

Year	Concessionaire	Partners	Estimated Length (km)	Type of Investment	Disinvesting Company
Oct 2016	EDP Transmissao S.A.	None	113	New	***
Apr 2017	EDP Transmissao MA I S.A.	None	128	New	***
Apr 2017	EDP Transmissao Alianca SC	None	753	New	***
Apr 2017	EDP Transmissao SP-MG	None	750	New	***
Apr 2017	EDP - Energias do Brasil S.A.	None	203	New	***
May 2019	EDP Transmissao Litoral Sul S.A.	None	164	M&A	CEE Power, Brafer

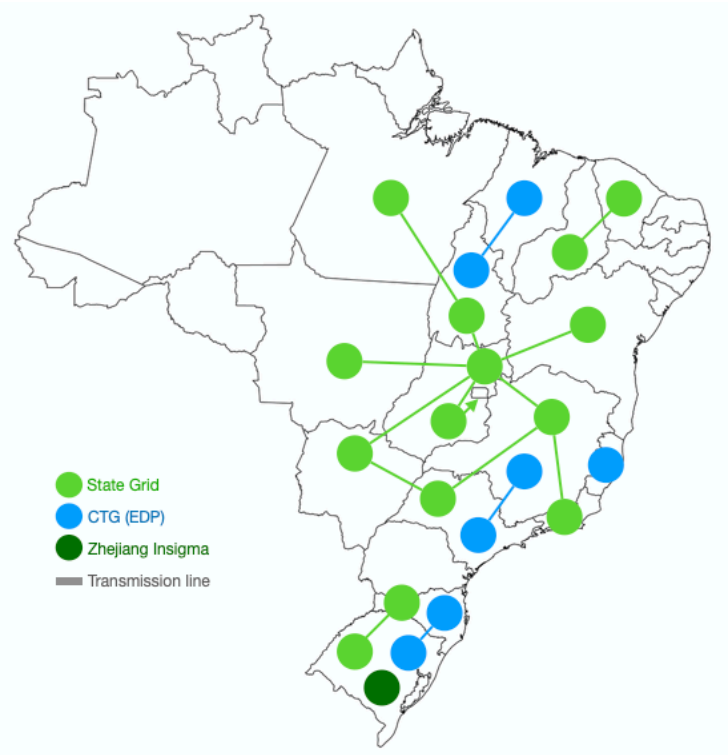
Source: Aneel.

CTG's footprint in Brazil's transmission sector started later through EDP. In 2016 and 2017, EDP successfully bid for five projects in different states. In 2019, it acquired Litoral Sul Transmissora de Energia, whose concessional rights belonged to Brafer and the Chinese CEE Power (EDP, 2019). In total, EDP's portfolio amounted to approximately 2,111 km of lines.

With the EDP's partial acquisition of Celesc, CTG got new minor indirect stakes in transmission projects in Santa Catarina. Celesc had shares in two local companies: Empresa Catarinense de Transmissao de Energia (31 percent) and Fronteira Oeste Transmissora de Energia (1 percent), which operate around 547 km in that state.

Shanghai Electric is another Chinese company that had plans to invest in Brazil's transmission sector, but it has not come through. In November 2017, in partnership with CLAI Fund, the firm signed an

Figure 23: Location of transmission lines per company



Source: Aneel.

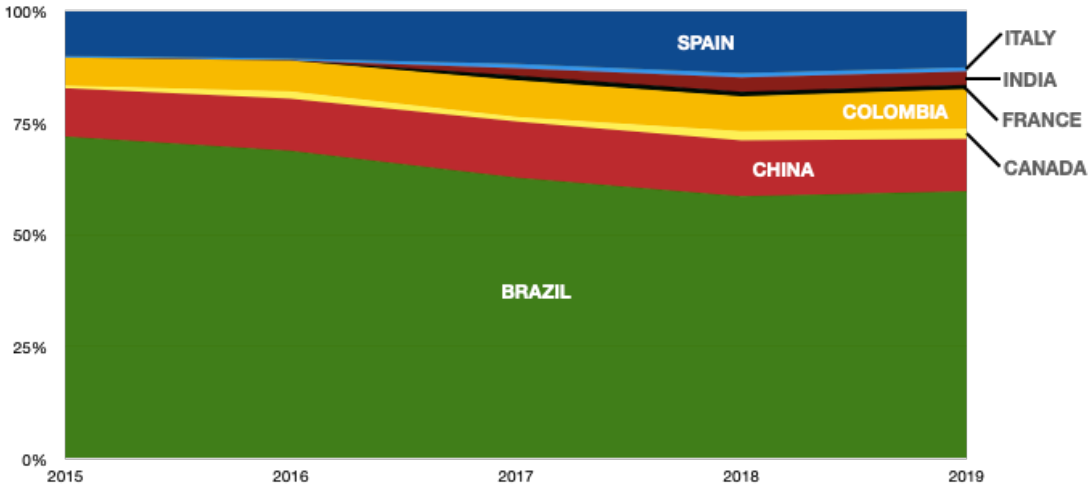
agreement with the state-owned Eletrosul, in order to jointly invest, construct, operate, and maintain 1,900 km of lines in Rio Grande do Sul. Both Chinese players would have 69 percent of the new society (Eletrosul, 2017). Eletrosul was looking for associates to help it financially fulfill the concessional rights won in public auctions. At some point, Zhejiang Energy has also showed interest in the transaction (MacauHub, 2018). However, all Chinese actors decided to withdraw from the deal (Aneel, 2018).

Geographically speaking, Chinese firms were present in all five regions, in 16 states. As expected, State Grid was the only one active in all regions. It had transmission lines crossing the country in different directions and with distinct voltages, ranging from 138 kV to 800 kV. CTG/EDP was more concentrated in Southern states, where historically EDP has a traditional stance, with the exception of a project between Maranhao and Tocantins. Their lines' voltages were between 230 kV and 525 kV. Lastly, Zhejiang Insigma possessed only one project in Rio Grande do Sul.

In contrast to the generation and distribution segments, where disaggregated data by state level is available, Aneel does not provide the length of transmission lines per region, only on a national basis, inhibiting a thorough assessment of the Chinese companies' assets in subnational terms. The closest one can get is through media reports, which estimated that State Grid controlled more than two-thirds of Rio Grande do Sul power grids in early 2017 (Weissheimer, 2017).

As was done in the former section, it is interesting to put Chinese investments in Brazil's transmission sector in perspective and evaluate the changes of the segment as a whole during the last few years. According to data available by Aneel, as in generation, there is a continuous process of internationalization of the segment over time, with foreign players starting or expanding their projects in the country.

Figure 24: Countries' percentage of the transmission sector (km of transmission lines)



Source: Aneel.

Brazilian power grid extension has consistently expanded throughout the years and companies from different countries have benefited from this phenomenon, their growth has presented different paces though. Chinese firms as a whole possessed roughly 12 percent of the national grid in 2019, ranking third place, after Brazilian (60 percent) and Spanish (13 percent) players. Nonetheless, it is worth highlighting that their development happened in a faster rhythm than other competitors, especially if one considers that their investments started in 2010, well after their international peers. Colombian (9 percent) and Indian (3 percent) actors have equally experimented a rapid development over time.

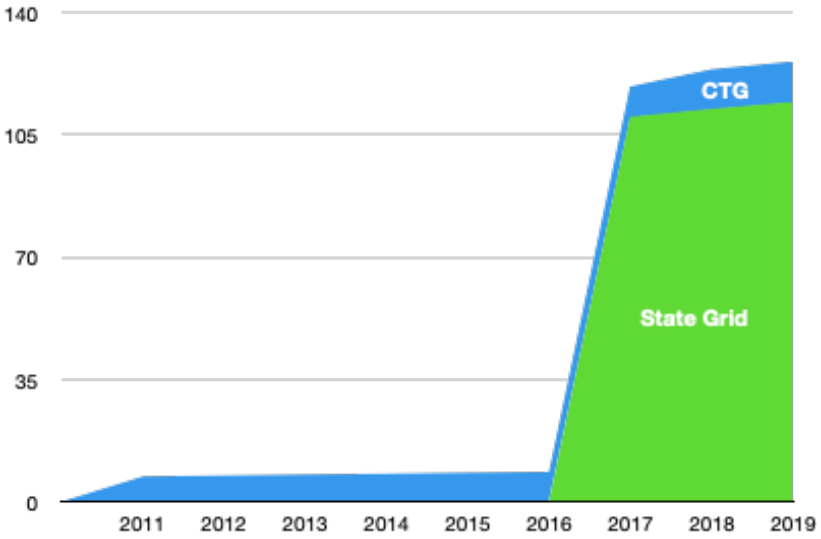
Brazil's power grid is largely dominated by domestic state-controlled firms, namely Eletrobras and its various subsidiaries. Transmission was almost exclusively under federal and state government control until 2007, when new sectorial regulatory laws emerged and, thus, other players started to enter (Husar, et al., 2013 p. 17). From then on, important players – other than Chinese – that have invested capital in Brazil were the Spanish Iberdrola, Cobra and others, the Colombian ISA Group, which controls CTEEP, and the Indian Sterlite, which disembarked in the country in 2017 through greenfield investments.

A report published by Getulio Vargas Foundation in 2018 about international participation in Brazil's transmission sector has used a different methodology – announced M&A – and another period of analysis – 2016-2018, but reached a similar conclusion: there is a continuous process of internationalization. Foreign private companies bought the majority of the power grid assets on sale by other investors in those years, or in Real (R$) terms, 85.2 percent (Oliveira, et al., 2018 p. 13). In auctions, international competitors' participation was 49.6 percent; SOE, particularly, won more than one-quarter of length of lines offered – 26.6 percent (Oliveira, et al., 2018 p. 16). As a result of these transactions, multinationals accounted for 22.8 percent of the sector, which is still dominated by local state-run concessionaires – 61.7 percent (Oliveira, et al., 2018 p. 35).

Distribution

Chinese companies' arrival in Brazil's electricity distribution sector coincides with the generation segment. The 2011 CTG's investment in EDP gave the former indirect assets in two local concessionaires: EDP ES and EDP SP. At the end of 2019, six other regional corporations – out of a total of 109 – had also Chinese full or partial ownership, namely Celesc, RGE, RGE Sul, CPFL Paulista, CPFL Jaguari and CPFL Piratininga (Aneel, 2020).

Figure 25: Number of consumer units per company (million)



Source: Aneel.

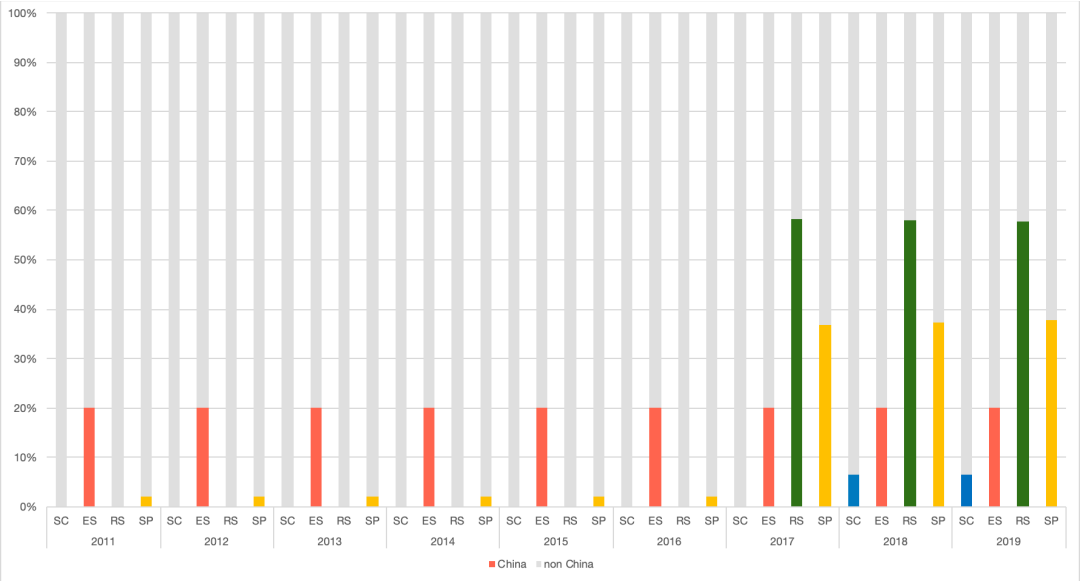
CTG and State Grid are the only Chinese firms with investments in distribution and all their transactions are M&As; no GFDI were identified in the period of this study. Since 2011, CTG's assets are through EDP Brasil – in which it has 21.47 percent –, which fully owned EDP Sao Paulo Distribuicao de Energia and EDP Espirito Santo (formerly Espirito Santo Distribuicao de Energia - ESCELSA). They provide electricity to Sao Paulo and Espirito Santo states correspondingly. In 2018, EDP Brasil started to buy shares of Centrais Eletricas de Santa Catarina (CELESC) (EDP, 2018) and ended up with 33.1 percent (Aneel, 2020).

In contrast, State Grid's presence started in 2017, with the acquisition of the Sao Paulo-based CPFL and its subsidiaries. As in the generation sector, State Grid's purchase of CPFL was equally strategic in the distribution segment. CPFL is historically one of the biggest electricity providers. A few months before this transaction, CPFL had just assumed the full control of RGE Sul Distribuidora de Energia and RGE Rio Grande Energia, both located at Rio Grande do Sul state (Costa, 2016). With CPFL's acquisition, the number of consumer units attended by Chinese firms expanded more than seven times.

Considering each Chinese company's shares in their local concessionaires, State Grid and CTG have the equivalent of 114 and 12 million consumer units, respectively, dispersed in four different states. In sum, they represented in 2019 roughly 12 percent of Brazil's distribution sector's consumer units (Aneel, 2020). Separately, the former accounted for 11 percent, and the latter, 1 percent.

Chinese companies were present only in four states, and their share in each of them has varied over time. In Espirito Santo (ES), EDP ES is the leading company, being responsible for the absolute majority of local residents' electricity. Considering CTG's indirect share of it, Chinese participation in the local distribution sector was around 20 percent, a percentage that remained stable over the years. In Sao Paulo, Chinese participation in the local distribution sector started small – roughly 2 percent until 2016, but augmented considerably after 2017, ending 2019 with 38 percent. The 2017 turning point was due to CPFL's acquisition. In Santa Catarina, Chinese participation started in 2018, when EDP partially bought 7 percent of Celesc. Finally, in Rio Grande do Sul, participation only started in 2017 and has remained 58 percent until 2019. This is due the fact that RGE is the state's major concessionaire, responsible for almost two-thirds of the local electricity distribution.

Figure 26: Chinese firms' percentage in the number of consumer units per state



Source: Aneel.

It is worth mentioning that Chinese companies strategically invested in regions with large populations and high GDP. The population of these four states altogether is over 68 million people, one-third of Brazil's entire population (IBGE, 2019). In terms of consumer units, correspondingly, they encompassed 34 percent of the whole country in 2018 (EPE, 2019). In addition, according to 2017 figures, they were responsible for 45 percent of the country's GDP; Sao Paulo alone had 32 percent of the total GDP (IBGE, 2020). Their four higher income rates also led to higher electricity consumption rates: the four states' average consumption is 37 percent greater than the rest of the nation. In terms of per capita consumption, they accounted for 33 percent of the national figure. (EPE, 2019).

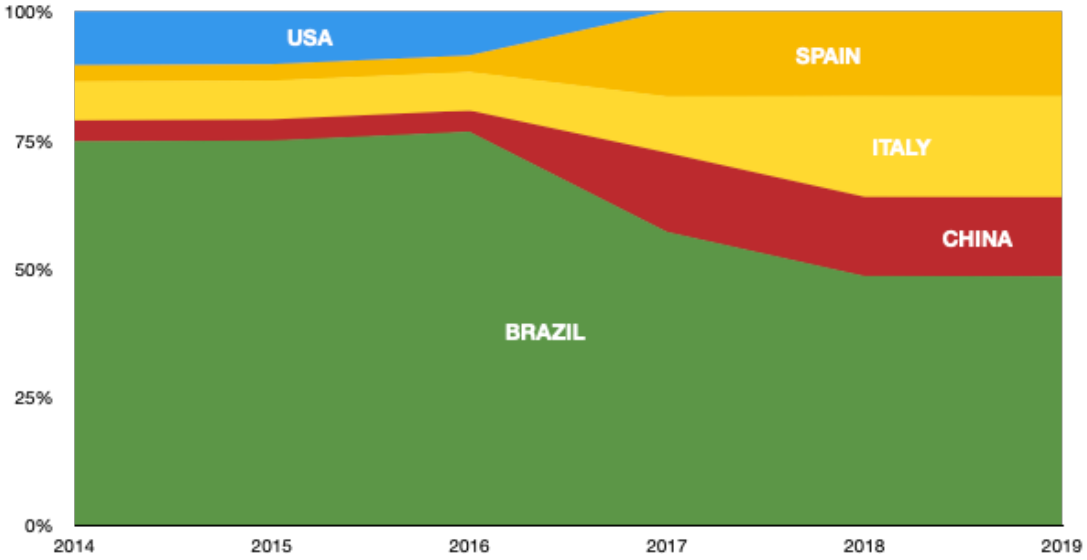
Similar to what was done in previous sections, here is presented an analysis of the performance of Brazilian and other countries' companies over the years to put them in perspective with Chinese firms. This exercise provides a better picture of China's expansion in Brazil's electricity distribution sector.

Examining data about the ownership structure of each of the one hundred plus distribution concessionaires in Brazil between 2014 and 2019 – period of time that there is complete data available (Aneel, 2020)[22], one may see a process of continuous internationalization of the segment, with foreign actors increasingly augmenting their stakes over time in substitution of local players.

Besides China, there are basically three other countries whose corporations have been traditionally present in the Brazilian distribution sector: Italy, Spain and USA. US firms and investment funds have been consistently investing in Brazil's energy sector since its opening, in late 90's. One of the main actors was AES group, with assets across all electricity segments. AES was the former owner of Eletropaulo and the Southern RGE Sul, which were acquired by Enel and CPFL respectively (CPFL,

[22] For methodological purposes, in this part, a concessionaire's nationality is defined according to the company or group of companies from the same country that have more the majority of the controlling shares of the local distribution firm. In this sense, Celesc is labelled as Brazilian, since the state of SC has 51 percent of the controlling stakes.

Figure 27: Countries' percentage of the distribution sector (number of consumer units)



Source: Aneel.

2016), leaving the USA with no other major assets in Brazil. Between 2014 and 2017, the share of the USA remained a little less than 10 percent.

Like the Chinese, Spanish and Italian firms have made big strides over the last few years. The main Italian player is the state-owned Enel, which is another well-known foreign player in Brazil. After two big acquisitions in 2016 and 2018 – respectively Celg-D, in Goias state (Costa, 2016), and Eletropaulo, it became Brazil's largest electricity distributor. The share of Italian companies between 2014 and 2019 varied from 7 percent to 20 percent.

The leading Spanish player is Iberdrola, which have investments in different electricity segments as well. In distribution, it arrived in the early 2000's and in the last few years has increased its shares and assumed bigger controlling stakes in its concessionaires. The share of Spanish firms between 2014 and 2019 grew from 3 percent to 17 percent.

A noteworthy feature of these shifts of ownership in the distribution sector is the nature of the companies involved. On the one hand, the decrease of Brazil's proprietorship shares in the segment happened mainly at the expense of domestic government-controlled corporations, whose assets were partially privatized over time. On the other hand, foreign state-owned firms were the major buyers of these concessionaires, as is the case of Enel and State Grid. In the end of 2019, these firms possessed roughly 36 percent of the entire sector.

This same process of internationalization of Brazil's distribution sector is described by the already mentioned 2018 report of Getulio Vargas Foundation. In all M&A operations between 2016 and June 2018, the buyer was invariably a multinational corporation, and 95.9 percent of the capital disbursed came from SOE (Oliveira, et al., 2018 p. 12)[23]. As a consequence, more than half of the segment – in GWh terms – was under foreign players' control and half of these actors were state-owned, such as CPFL and Enel (Oliveira, et al., 2018 p. 37).

[23] There were no auctions in those years.

CONSTRUCTION, REPAIR, OPERATION AND MAINTENANCE: CHINESE ENGINEERING AND MANUFACTURING COMPANIES' ACTIVITIES IN BRAZIL

Alongside the players directly involved in electricity generation, transmission and distribution, another group of Chinese actors has decided to go to Brazil to offer engineering, procurement, and construction (EPC) services, supplies of material inputs and equipment – solar panels, batteries, wind turbine generators etc. – and to perform project operation and technical maintenance (O&M). In this process, some have installed themselves in Brazil permanently, aiming at establishing a solid foothold in the local market. Indeed, their arrival in the country much preceded the former group, whose first deal was in 2010 with State Grid. Since 2005, construction related projects amounted to US$1.5 billion[24].

Coal related projects comprised the greater part of these capital. Chinese players own only one coal station in Brazil, the Porto de Pecem I, in Ceara, which belongs to EDP. Yet, they were more active in building and reforming other plants. In fact, the inaugural Chinese project in Brazil – back in 2005 – was the designing and building of the Candiota coal plant's Phase C, a contract worth US$428 million (SECEX, 2006). The great part of the machinery and equipment came from China, mainly from Harbin Turbines, Harbin Generator Company Limited and Harbin Boiler (Reed, et al., 2018).[25] Several years later, in 2018, CITIC was once again hired by Eletrobras for the maintenance of Candiota III, in a contract of US$71 million (JornaldoComercio, 2018).

CITIC was not alone in coal projects in Brazil. Sepco1 Construcoes do Brasil, a company part of the Power China group – the world's seventh largest international contractor (ENR, 2019) –, was hired to build two other coal plants in the South: the Pampa Sul in 2014 (a EPC contract of US$649 million) (Cobrazil, 2019) and the Ouro Negro, whose construction started in 2019 (US$970 million) (JornalMinuano, 2019). Besides these plants, the company was also negotiating the gasification of the Southern coal. In November 2015, it signed a memorandum with a regional firm and the Rio Grande do Sul's agency for investment promotion on this subject (Weissheimer, 2017).

Table 4: Chinese electricity EPC and machinery firms in Brazil (confirmed and announced investments)

Manufacturers	Znshine Solar	S4 Solar	HT SAAE	Trina Solar	Sinovel	XJ Wind Power
	Yingli Solar	Zhejiang Chint Electrics	Corona Energy Technology	CED Prometheus	Grand Will	Goldwind
	Hanergy	Canadian Solar	JA Solar	BYD	Shenzhen Center Power	
EPC	China Cable Corporation	Fujian Electric Power Engineering	Zhejiang Electric Power Transmission	Shandong Electric Power (SDEPCI)	Zhejiang Shengda Steel Tower	CRRC Times Electric Brasil
	China National Electric Engineering (CNEEC)	China Electronic Power Equipment and Technology	Hunan Power Transmission & Substation Engineering	East China Power Transmission & Substation Engineering	Xinjiang Power Transmission & Substation Engineering	XPTT Brazil Electrical Power Systems Construction
	Sepco1	Jinlihua Electric	NARI	CITIC	Dongfang Electric Corporation	

Sources: multiple.

[24] Only services included in these numbers.

[25] CITIC was accused of illegally hiring between 450 and 500 Chinese workers, which have entered the country as tourists, but actually were working in the construction site (Weissheimer, 2017).

Electricity transmission was another sector that has attracted several engineering corporations to Brazil and involved considerable sums of capital, although this amount is difficult to track. This movement can be considered a natural consequence of State Grid's increasing stakes in the Brazilian segment over the years.

In projects all over the world, Chinese companies have historically worked in a coordinated way, i.e. Chinese companies subcontracting other Chinese engineering service providers. In Brazil, it was not different. The construction of the Belo Monte lines is an example. Sepco1[26], China Electric Power Equipment and Technology, Xinjiang Power Transmission & Substation Engineering, East China Power Transmission & Substation Engineering, Hunan Power Transmission & Substation Engineering, Fujian Electric Power Engineering, and XPTT have all got EPC contracts in the Belo Monte project (Hiratuka, 2018 p. 131).

In the same way, Chinese firms have traditionally relied on machinery imports from China to support their overseas projects[27]. In the case of State Grid, it has progressively verticalized and integrated its operations over the years. In 2009, it acquired 60 percent of China's largest smart-metering manufacturer, Xuji Group (Husar, et al., 2013 p. 25). The subsidiary Nari (Nanjing Automation Research Institute) deals with industrial automation and 800 kV technology. Both companies have participated in Chinese projects in Brazil. Xuji installed itself in State Grid's headquarters in Rio de Janeiro (Cote, 2014 p. 22). Nari opened an office in Sorocaba (Nari, 2020) and had its high-tech 800 kV equipment applied in the Belo Monte line project (NariBrasil, 2015), like other Chinese electrical manufacturers, such as China XD Group, PG Group (Hiratuka, 2018 p. 131).

It is true that before the Belo Monte transmission line project, other Chinese firms have already worked in Brazil. China National Electric Engineering Co. (CNEEC), Zhejiang Electric Power Transmission & Transformation Corporation of China, China Cable Corporation, and Zhejiang Shengda Steel Tower Company all participated in the construction of Tucurui dam's lines, back in 2008 (Xiaoshan19lou, 2012).

The sector that has attracted the highest number of Chinese actors was solar energy. At least 12 firms invested or announced investments in Brazil. Some of them revealed plans to install manufacturing facilities in the country, but, with some exceptions, none of these proposals have become reality.

In 2012, AstroEnergy announced that it would provide 46 thousand solar panels to a US$350 million project in Ceara (DiariodoNordeste, 2012). In 2017, Zhejiang Chint Electrics, owner of the former, announced the opening of a solar module factory in Rio Grande do Norte (AgoraRN, 2019). A year later, it announced its participation in another solar project, this time in Ceara (Bellini, 2018).

In 2013, Hanergy announced the construction of a solar factory in Rio Grande do Sul (Nepomuceno, 2013). Five years later, these plans were transferred to Minas Gerais, but their implementation could not be verified (Alves, 2018). Other companies that announced manufacturing facilities in Brazil were S4 Solar (NE10, 2016), CED Prometheus (Araujo, 2018), Corona Energy Technology (Santana, 2018), Jinlihua Electric (Tang, 2018) and HT SAAE (Shanghai Aerospace Automobile and Electromechanical) (Ribeiro, 2019).

As a whole, most of the companies walked back their factory announcements, and some preferred just to operate through local offices and then offer services and imported solar modules. That was

[26] Sepco1 has faced some difficulties in the Amazon terrain during the construction of the first phase, in which it was responsible for building three of the eight parts of the line (roughly 38 percent of the total) (BMTE, 2014). In order to avoid delays in the project, BMTE has hired seven additional constructors to fulfill its obligations on time (Borges, 2017).

[27] Besides market and price conditions, imports of Chinese service and machinery is a common clause in loans provided by the policy banks' China Development Bank and CHEXIM (Barbosa, 2020).

the case of Znshine Solar Brasil, Jinko Solar, Trina Solar (Costa, 2017), JA Solar (JASolar, 2020) and Yingli Solar. This last one installed PV panels on the rooftop of football stadiums during the 2014 World Cup (Fifa, 2014).

S4 Solar, BYD and Canadian Solar were the only ones whose investments came to reality. The former installed itself in Pernambuco, but has already closed its doors (Scrivano, 2018). The second inaugurated its second industrial facility in Brazil, in 2017, focusing on increasing its share in the country's solar panel market (Apex, 2017). The latter, in partnership with a local firm, opened a solar module facility in Sorocaba, aiming at providing solar cells to its own generation projects (Lopez, 2016).

A possible explanation for Chinese solar players' reluctance to implement their plans in Brazil is the lack of a national policy for photovoltaic energy generation and grid integration (Cuperstein, 2014 p. 15). Some authors suggested governmental incentives did not happen during the period of this study (Scrivano, 2018).

Despite the fact that the Brazilian wind energy industry has been among the fastest growing in the world over the last few years, surprisingly and in contrast to solar energy, there were no Chinese companies in Brazil to produce aerogenerator and wind power components until 2019. The market is dominated by other foreign and some local players (ABDI, 2014). A possible reason is that, back in 2014, these firms were starting go abroad and initially prefer to whole-sale exports of their manufactured equipment, instead of establishing local production facilities (Cuperstein, 2014 p. 15).

The most active Chinese company is Xinjiang Goldwind Science & Technology. Although it is number three in the world in terms of new wind power turbine installations in the world, its presence in the country is very small, at least until 2018, with just an office in Sao Paulo (Proctor, 2020). However, several sources indicated that it is looking for opportunities to have a bigger presence in the Brazilian market. It has also possibly shown interest in acquiring 70 percent the debt-ridden Energimp, one of the major actors in the local market (Reuters, 2017).

Beyond speculations, in June 2018, Goldwind debuted in Brazil, when it was hired by the state-owned CHESF to complete the construction of a wind power complex in Bahia (Costa, 2018). Three weeks later, another deal – this time a big one – came through: US$270 million to restore, replace or repair 242 turbines of the failed Energimp in the Northeast, with a total capacity of 363 MW (Goldwind, 2018). These deals were facilitated by the fact that Goldwind was then the sole locally authorized firm to use the German Vensys' technology, whose equipment was widely used in Energimp projects in Brazil (Costa, 2018).

Before Goldwind's arrival, the only concrete Chinese wind project in Brazil was Sinovel's participation in a Desenvix-run wind farm in Sergipe (Sinovel, 2011). The Brazilian company Desenvix became the first South American developer to buy Chinese wind turbines (EnergiasRenovables, 2011). Nevertheless, the deal ended up in a court litigation (Quilter, 2012).

A natural consequence of Chinese firms' growing presence in construction projects in Brazil, either as constructors or as providers of machinery and equipment, would be increasing imports of materials and technology from China. As argued above, scholars have asserted that Chinese players tend to act in an integrated way, either by contractual terms – such as deals backed by policy banks' loans (Barbosa, 2020) – or by intra-company commerce, like the case of State Grid and its subsidiaries. This hypothesis is difficult to prove, since the Brazilian government no longer show trade data on the company level, making it impossible to check through official channels the volume of imported content. Thus, related studies about the participation of Chinese players in the national supply chain for the electric sector are also hindered by this limitation (Hiratuka, 2018 p. 139).

Some indications, however, can be seen in media reports and specialized academic works. According to data released by the Brazilian Association of Solar Energy (ABSOLAR), photovoltaic panels and equipment's imports from China over the last five years have exponentially increased. The figures reached US$1 billion in the end of 2019 – from almost zero in 2014 –, and 99 percent of them having China as an origin (Pinto, et al., 2020).

A similar situation might have happened during the construction of the Belo Monte transmission lines. According to Hiratuka, in Phase II, about US$714 million was spent on imports of Chinese high-tech power equipment and EPC services (Hiratuka, 2018 p. 131). According to the President of Xingu Rio Transmissora de Energia (XRTE), responsible for building and administrating the line, roughly 40 percent of all equipment came from China (Pamplona, 2017).

JOINING HANDS WITH LOCAL PARTNERS: CHINESE ENERGY FINANCE IN BRAZIL'S ELECTRIC SECTOR

In contrast to the Brazilian oil & gas sector, which was the main target of Chinese banks over the last years (Barbosa, 2020) (Gallagher, 2019), China's loans to Chinese and local electric players were fewer in number and less in value, according to data available[28] [29] [30]. Based upon the type of financial institution, it is possible to divide these credits in three distinct groups: loans from Chinese policy-banks, regional funds and multilateral banks; from Chinese commercial banks operating in Brazil; and from Brazilian banks. Notably and distinctively, Chinese regional funds, such as the CLAI Fund, CLAC Fund, and CPSC Fund, invested heavily in equity, joining hands with other Chinese electricity firms to buy assets in Brazil.

Table 5: Loans to Chinese electricity projects in Brazil

Date	Lender	Borrower	US$ Million	Sector	Source	Objective	Status
Dec-19	BNB	Canadian Solar	55.66	generation	solar	Construction of solar farms Lavras 1 to 5	confirmed
Sep-19	CDB	Ouro Negro S.A.	776.00	generation	coal	Sepco1 EPC contract for the construction of Ouro Negro coal plant	announced
Aug-19	BNB	Canadian Solar	120.00	generation	solar	Construction of solar farms Francisco Sa and Jaiba	announced
Aug-19	BNB	Canadian Solar	22.99	generation	solar	Construction of solar farm Jaiba 4	confirmed
Jan-19	BNB	Canadian Solar	80.00	generation	solar	Construction of solar farm solar Salgueiro	announced
Nov-18	BNDES	State Grid	1384.00	transmission	hydropower	Construction of Phase II of Belo Monte transmission lines (XRTE)	confirmed
Nov-18	BNDES/BID/ BNB	Canadian Solar	373.00	generation	solar	Construction of solar farm Pirapora	announced

[28] In this section, both confirmed and announced loans are taken into consideration. The announced ones are clearly indicated over the text.

[29] As in other sections, the amount in US dollars is calculated according to the official exchange date at the date of the loan's approval.

[30] For methodological reasons, the numbers presented in this work just reflect bank loans, not including other forms, such as bond financing – debenture bonds –, capital subscription etc.

Table 5: Loans to Chinese electricity projects in Brazil (continued)

Date	Lender	Borrower	US$ Million	Sector	Source	Objective	Status
Oct-18	BNDES	State Grid	48.56	transmission	hydropower	Construction of transmission lines in the Center-West (Canarana Transmissora de Energia S.A.)	confirmed
Apr-17	NDB	BNDES	300.00	electricity	renewables	Finance 5 renewable energy and transmission projects	confirmed
Mar-17	CPSC Fund	Canadian Solar	20.00	generation	solar	Construction of solar farm Pirapora I	announced
Feb-17	BNDES/CEF	State Grid	829.28	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Dec-16	CDB	BYD	294.00	manufacturing	solar	Expansion of production of electric buses and solar panels	announced
Nov-16	ICBC do Brasil	State Grid	11.69	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Nov-16	China Construction Bank Brazil	State Grid	111.34	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Nov-16	Banco Pine	State Grid	7.31	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Nov-16	ABC Brasil	State Grid	23.19	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Oct-16	Bank of China Brasil	State Grid	8.03	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Oct-16	Banco Pine	State Grid	7.93	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Aug-16	ICBC do Brasil	CTG	1012.37	generation	hydropower	Finance purchase of Ilha Solteira and Jupia hydropower dams	confirmed
Jan-16	BNDES	State Grid	177.22	transmission	hydropower	Construction of Phase I of Belo Monte transmission lines (BMTE)	confirmed
Oct-15	Bank of China Brasil	State Grid	3.89	transmission	hydropower	Construction of transmission lines in the Center-West (Luziania-Niquelandia Transmissora S.A.)	confirmed
Sep-12	CDB	Desenvix	56.00	generation	wind	Construction of wind farm Barra dos Coqueiros and purchase of Sinovel equipment	confirmed
May-08	CDB	Eletrobras	281.00	generation	coal	Construction of the Candiota power plant by CITIC	confirmed

Sources: multiple.

Loans from Chinese policy-banks, regional funds and multilateral banks in which China is a leading member amount to US$1.7 billion in the period of this study. The first ever Chinese credit to the Brazilian electricity sector happened in 2008, when CDB gave US$281 million to the construction of the Candiota coal power plant by CITIC (Eletrobras, 2020). Four years later, the Brazilian wind firm Desenvix Energias Renovaveis received US$56 million from CDB to finance a wind farm in Sergipe. The project developer was Sinovel (Sinovel, 2011). In December of the same year, BYD announced that they received a credit line from CDB worth US$294 million to invest in its production of electric buses and solar panels in Brazil (GazetadoPovo, 2016).

In March 2017, Canadian Solar announced a US$20 million loan from CPSC Fund, to be used in its then recently acquired Pirapora solar farms (Lopez, 2017). However, in the end of 2019, the same project was registered as belonging to EDF in Aneel, implying that Canadian Solar might have transferred its concessional rights (Aneel, 2020). The multilateral BRICS-led New Development Bank also stepped into Brazil's renewable energy sector. In April 2017, it lent US$300 million to the Brazilian Development Bank (BNDES) to finance five power generation and associated transmission projects (NDB, 2017). Lastly, in 2019, it was announced that CDB would provide 80 percent of the total financing necessary to build the thermoelectric Ouro Negro, whose EPC contract belonged to Sepco1 (JornalTribunadoPampa, 2019).

The analysis of Brazil-China finance cooperation in the electricity sector provides some important insights on Chinese commercial banks activities in Brazil, a topic whose examination has not received much space in the specialized literature on Brazil-China and China-Latin American relations. Up to 2019, around US$1.2 billion was lent by these institutions. State Grid and its subsidiaries were the main benefactors. Luziania-Niquelandia Transmissora, society in which Furnas also participates (49 percent), borrowed almost US$4 million from Bank of China Brasil S.A. (LNTrans, 2017). The other loans were all related to the Belo Monte project, whose big engineering scale demanded a complex and diversified financial structure. The Brazilian branches of ICBC, China Construction Bank, Agricultural Bank of China and Bank of China have contributed with US$11.7 million, US$111.4 million, US$23.2 million and US$8 million, respectively (BMTE, 2016).

CTG has also worked with locally-established Chinese banks. In 2016, through its subsidiary Rio Parana Energia, it borrowed from ICBC over US$1 billion to pay for the Ilha Solteira and Jupia hydropower dams (RioParanaEnergia, 2017).

Brazilian financial institutions' loans to Chinese electricity projects in Brazil, in contrast, amounted to US$3.1 billion[31]. Brazilian state-led banks, such as BNDES, Caixa Economica Federal (CEF), and Northeast Bank of Brazil (BNB), assumed an important role. The Belo Monte transmission lines have consumed the greatest part of this capital. In total, BNDES has provided as much as US$2.4 billion to the project, partially with the help of CEF (BMTE, 2015) (BNDES, 2017) (BNDES, 2018). The local private bank Pine equally financed it, with a bit more than US$15 million (BMTE, 2016).

Besides the Belo Monte case, State Grid-controlled Canarana Transmissora de Energia S.A. borrowed US$49 million from BNDES to expand its activities in the Center-West. Moreover, Canadian Solar was also very active in resorting to local funding. In 2018, it announced a US$373 million-loan from BNDES, the Inter-American Bank of Development (BID) and BNB to be applied to the above-mentioned Pirapora solar project (Bellini, 2018). In 2019, two more announcements were made, totaling US$200 million, both with BNB's funds (Bellini, 2019) (Molina, 2019). Resorting to data from BNB, two other credit lines amount to US$79 million were opened in the same year to finance the solar farms Jaiba and Lavras (BNB, 2020).

It is essential to highlight that the active participation of Brazilian state-run banks in China-led generation and transmission projects have a dual importance. On the financial side, providing local currency loans might effectively reduce the financing costs related to medium and long-term currency fluctuations, besides reducing the demand for other financing channels, such as debenture bonds and capital subscription. State-backing might have also helped to attract other investors and financiers to these projects (Cui, et al., 2019 p. 248). From the political aspect, these banks' presence not only shows the commitment of the Brazilian government in fostering the improvement of the

[31] BNDES relationship with Chinese electricity companies is not recent. In 1997, BNDES offered CDB US$208 million to finance imports of Brazilian machinery and equipment used in the construction of the Three Gorges dam. The 19-year-old loan was fully paid by CTG in the end of the contract's term (BNDES, 2020).

country's electric sector, but also highlights the importance of Chinese investments and technology in helping to overcome local infrastructure bottlenecks.

As a distinct character of the bilateral financial cooperation in the electric sector, Chinese state-led regional funds CLAI, CLAC and CPSC have decided to directly own electricity assets in Brazil. As discussed in the previous sections, CLAI Fund has amassed as much as 2.3 GW in hydropower projects, whereas CLAC and CPSC had each a 7 percent stake in Sao Simao dam. The participation of Chinese funds as buyers in Brazil's electric sector is not unique. In the last few years, several international funds directly bought assets in the country (Oliveira, et al., 2018 p. 11).

Lastly, putting Chinese loans in Brazil's electric sector in a broader perspective, two notable features come out. According to China's Global Energy Finance database, which tracks policy banks' financing, Brazil represented only a small fraction of China's overseas coal-related lending, roughly 2 percent of all loans in the same source (Gallagher, 2019). Moreover, the pattern of few loans in the Brazilian wind and solar segments is consistent with China's overall lending, in which these renewables received 2.6 percent of the total (Kong, et al., 2020).

"RAISON D'ÊTRE" OF CHINESE INVESTMENTS IN BRAZIL'S ELECTRIC SECTOR

With so much capital poured into Brazil's electricity sector in the form of FDI, construction projects, and loans over a relatively short time, especially comparing with numbers of Chinese investments in other countries' same industry, it is reasonable to ask: what are the main drivers and rationale behind this push? In this study, it is argued that three concomitant factors helped to explain this phenomenon, namely (i) implementation of China's "going global" strategy, (ii) Brazil's rich natural and energy endowment and (iii) favorable market conditions.

"Going out" strategy

The "going out" strategy is a government strategy launched as early as 2001, with the aim of fostering the international expansion of Chinese companies (Kong, 2019 p. 38). Kong and Gallagher argue that there are basically four drivers behind it, namely to (i) improve the nation's resource security (resource seeking), (ii) promote national exports of goods, services, and capital (market seeking), (iii) enhance the country's technological skills (efficiency seeking), and (iv) foster Chinese companies' global competitiveness and presence in international markets (strategic assets seeking) (Kong, et al., 2020 p. 8). These objectives are ensured via the joint action between SOE – the dominant investors in overseas energy markets (Li, et al., 2018 p. 8) – and the Chinese policy banks' CDB and CHEXIM, the financial backbones of the national firms' internationalization (Ma, et al., 2019).

The authors also acknowledge that SOE are part of an intricate and complex institutional coordination. Eight central bureaucracies, half related to energy and half to finance, align SOE's international expansion plans with the necessary government financial backing and the country's overall development objectives (Kong, et al., 2017 p. 11). Broadly speaking, these objectives are connected to the attainment of the "two centenary goals", which entail the achievement of a "moderately prosperous society in all respects" by 2021, the 100th anniversary of the Communist Party of China, and of a "great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious and beautiful" by 2049, when the founding of the People's Republic of China will turn 100 years-old (Kong, 2019 p. 27). In this mode of operation, entrepreneurial and market-oriented calculations on the one hand and political considerations on the other hand are balanced, integrated and tied together.

In the particular case of renewable energy projects, the first driver presented above seems unfit, since it is commonly seen in extractive industries, such as oil and agricultural foodstuff, and cross-border electricity exports are still mainly limited to bordering countries. Nevertheless, the remaining three give a reasonable explanation of the outburst of Chinese energy investments and finance over the last years.

MARKET SEEKING

Promotion of exports is an instrument more commonly seen in the case of goods and commodities, but it is also usual in services, with infrastructure and energy sectors as typical examples. The governmental encouragement and financial support notwithstanding, the outward expansion of Chinese electric firms is a process based upon in two more pillars: accumulation of technical prowess and managerial expertise and diminishment of economic opportunities inside China (Becard, et al., 2020 p. 56). Both pillars are consequences of the country's rapid economic development over the last decades.

In the country's push for modernization, especially from the late 1970s, engineering firms – mainly SOE – were assigned with the task of building and improving the national infrastructure. For decades, indeed, Chinese double-digit economic growth was more related to investments than consumption. Naturally, over time, companies have been accumulating technical prowess and considerable onsite experience in several fields. In 2011, China surpassed the US as the country with the largest installed capacity and the biggest electricity generator (EPE, 2019).

The case of the electricity transmission sector, with State Grid and the UHV technology, illustrates this phenomenon. The company covers 88 percent of China's vast territory and more than one billion people (CPFL, 2020). Similar to Brazil, the long distances between major electricity consumption centers and generation regions created the necessity of lengthy transmission lines and efficient technology.

Hydropower generation was not an exception. After years of continuous expansion of the nation's installed capacity with the construction of large dams – the case of Three Gorges as an example – firms like CTG became increasingly sophisticated and competitive in their fields, augmenting the possibilities of a successful undertaking abroad.

In the coal sector, it was no less different. China's energy matrix strongly based on fossil fuels, mainly coal, has helped the country to become by far the world's biggest consumer and producer. In 2018, Chinese coal production was as big as the remaining nine top producers altogether. Similarly, its national consumption represented half of the global one (BP, 2019). This situation has prompted the development of a whole set of related industries.

Another consequence of years of high rates of economic expansion is a natural shrinkage of business opportunities inside the country. In many sectors, over the last years, China has started to experience overcapacity, saturation of the domestic market and increasingly strict internal environmental regulations. This tripod has made the option of looking overseas for new undertakings seem a logical decision, so firms could continue to take advantage of their expertise. Schutte and Debone mention an interview from Bi Yaxiong, an executive from CTG, in which he associated the future lack of large-scale hydropower plant development plans in China with the company's global expansion and investments in Brazil (Schutte, et al., 2017 p. 107).

It is not surprising, for example, that the coal and hydropower sectors were the ones that, after oil, represented the majority of the projects funded by CDB and CHEXIM over the last decades (Ma, et

al., 2019). Analogously, most of Chinese-controlled generation plants abroad are of coal and hydropower (68 percent) (Gallagher, et al., 2019).

No less important is the possibility of expanding China's energy finance abroad through the work of the government's financial arms' CDB and CHEXIM. The international expansion of Chinese energy firms has much of its merits coming from the low interests and favorable repayment conditions offered by these policy banks to national firms. For local corporations in host countries, the existence and extent of these advantageous conditions is questionable and have stirred up extensive discussions in the academic sector. Yet, for countries whose access to international financial markets is limited or inexistent, both institutions are undeniably an important financer.

CDB and CHEXIM jointly became the main energy finance providers in the world, surpassing traditional western institutions, such as the World Bank. This performance becomes even more important considering that it favors the diversification of China's colossal foreign exchange reserves and, in some cases, the internationalization of the renminbi, when the loan is not based on dollars terms (Kong, et al., 2017 p. 10).

EFFICIENCY SEEKING

Expanding abroad brings also the challenge of testing and polishing home-bred technologies in alien terrains. The successful implementation of native techniques abroad is an important experiment for the operation competence, technologic efficacy and business reputation of Chinese firms.

Over the years, Chinese companies have developed cutting-edge technologies in a several energy-related realms, ranging from hydro-engineering, nuclear energy, wind turbines, thermal power plants, photovoltaic (PV) cells, batteries, electric vehicles, energy efficiency techniques, energy transmission, power grids, smart grids, and so forth and so on. Accordingly, they have become leading exporters of energy products and services in these same fields. Nonetheless, there is still another big set of capabilities in which domestic development did not achieve the expected results and companies have relied on international cooperation to bridge these gaps. The case of Chinese investments in Brazil's pre-salt oil seems a good example, because of the South American country's breakthroughs in deep-water oil exploration.

In the particular case of the electricity sector, there seems to exist an underlying logic of projecting technological leadership and, at the same, internationally standardizing technical codes, models and systems, and possibly benefiting Chinese developers (Schutte, et al., 2017 p. 106). The launching of the Global Energy Interconnection Development and Cooperation Organization (hereinafter GEIDCO) in March 2016 might be a good example (GEIDCO, 2020). Its objective is to establish a global energy configuration platform – the Global Energy Interconnection (GEI) –, which will be a "globally interconnected strong and smart grid supported by Ultra High Voltage (UHV) backbone grids and dedicated primarily to the transmission of clean energy" (GEIDCO, 2018).

In the Brazil-China electric cooperation, the application of Chinese world-class technologies might be a useful tool to reinforce mutual trust (Schutte, et al., 2017 p. 106). In this sense, some Chinese firms' decision of establishing partnership with local companies seems to reflect this logic. State Grid's first UHV project in Brazil – and outside China –, the Phase I of Belo Monte, was in partnership with the state-owned Furnas and Eletronorte. Additionally, it has partnered with Eletrobras' research arm, Electric Power Research Center (CEPEL), the Operator of the National Electricity System (ONS) and the Energy Research Office (EPE), aiming at working collectively on high-voltage transmission technology and smart-metering systems (Cote, 2014 p. 21).

ACQUISITION OF STRATEGIC ASSETS

Promotion of exports and improvement of domestic technology happen in tandem with the acquisition of strategic assets. Indeed, the latter can provide more opportunities for the continuous expansion of the former two. An analysis of some Chinese electric investments in Brazil help to explain this association and evaluate its results.

The case of the Belo Monte transmission lines is a good example, because of its strategic importance for the firm itself and for the hosting country. The project gave State Grid's UHV technology the chance to "go out" for the first time. Moreover, as said above, the venture allowed some Chinese constructors to establish and/or expand their activities in Brazil, not to mention increasing related equipment exports. Besides, it has created the challenge of adapting it to a brand-new environment, whose diverse conditions would help the company to improve its own technical and organizational know-how. It is worth to remember that Sepco1, responsible for some branches of the project, has confronted difficulties dealing with the extra-humid Amazonian terrain, torrential rainfalls and sometimes hostile local communities, causing delays in the project and receiving administrative fines and sanctions (Borges, 2017).

The strategic importance of this project for State Grid can be measured by its behavior during the whole process. The choice of joining hands with two relevant local companies could facilitate the acceptance and the adaption of its technology to the new terrain. It could also diminish eventual opposition that foreign companies face when investing in sensitive areas in other countries.[32] State Grid has also bid well below the government-set ceiling in this and other auctions for large transmission contracts. In both Belo Monte auctions, the discount was of 38 percent and 19 percent. In two bundles of lines auctioned in March 2012, in partnership with Copel, the discount reached 40 percent on average. For some authors, these moves would exemplify the company's disposition to sacrifice high returns, in exchange of possessing strategic assets (Cote, 2014 p. 20)[33]. For others, it shows its willingness to make huge financial and engineering investments in exchange of long-term returns (Cui, et al., 2019 p. 241).

The example of CPFL's acquisition is equally telling, for also being strategic for the Chinese firm's expansion in Brazil. In one transaction, State Grid not only extended the length of Brazilian transmission lines under its control, but also instantaneously became one of the country's most relevant players in generation and distribution. The company's array of activities has stretched to all five regions, augmented in the most populated and rich areas, and diversified in terms of sources of energy. Essentially a transmission company in China, State Grid, by contrast, became a full-range electricity company in Brazil, expanding horizontally and vertically its capabilities and assets.

[32] Over time, State Grid has been facing substantial hurdles and setbacks in some of its ventures abroad. Arguing national security risks associated with leaving strategic services under the control of foreign state-owned corporations, political opposition and business restrictions have grown in different countries. In 2016, Australia rejected bids from State Grid to acquire the national biggest energy grid, Ausgrid (Ng, 2016). In July 2018, the German government indirectly barred State Grid's acquisition of 20 percent of 50Hertz, a local operator of transmission lines, through its national development bank KfW, which ultimately bought the stake. A similar attempt from the Chinese firm in March 2018 was also unsuccessful (Oliveira, et al., 2018 p. 46). In 2019, State Grid's 40 percent stake in the National Grid Corporation of the Philippines (NGCP), a private consortium that operates the majority of the local power lines, was negatively questioned in local leaked reports, which claimed that only Chinese engineers had access to key parts of the system and that provision of energy could in theory be disactivated remotely on Beijing's orders (Griffiths, 2019).

[33] The same author pointed out that generous discounts, which happened mainly in the beginning of the company's expansion in Brazil, could indicate State Grid's lack of familiarity with local bidding process (Cote, 2014 p. 20).

Brazil's abundant energy endowment

Coupled with Chinese eagerness to expand its export markets and finance destinations, test and perfect abroad its technologies, and buy out strategic assets, the local abundant energy endowment was another factor that attracted players from China and many other countries to Brazil. Comparatively to other nations, either more than ten years ago, when Chinese firms began investing there, or more recently, Brazil's vast untapped energy resources have always offered a land of business opportunities and exploitation potentialities. Moreover, the electricity matrix based on renewables, mainly hydropower and growing wind and solar, has acted as another appealing catalyst for new ventures and M&A, considering China's rich experience in these sectors and its investments' preferences linked to local resource availability.

According to Climatescope 2019, a yearly report prepared by Bloomberg NEF about investment conditions for clean energy in emerging markets, Brazil was the world's third most attractive country for FDI in renewables – number two in early editions –, one position above China. Additionally, it was the biggest recipient in Latin America (35.2 percent) (BloombergNEF, 2020). In the period 2009-2018, it was the fourth primary emerging market recipient of Chinese FDI in clean energy (Climatescope, 2020). According to the International Renewable Energy Agency (IRENA), the country also had the third largest renewable energy generation and installed capacity (IRENA, 2020) and globally ranked fourth in terms of new investments in renewables from 2004 to 2018 (IRENA, 2020).

Separating the analysis per source of energy, findings continue to show the country as a prominent recipient of energy investments. In 2019, Brazil had the world's second largest hydropower installed capacity, after China (IRENA, 2020), but, remarkedly, it still has much of its potential to be explored. This potential is explained by the country's extensive territorial surface, with many plateaus and large rivers. The country's current hydroelectric potential is estimated at 172 GW, of which 60 percent is already used. Approximately 70 percent of this non-realized potential is located in Amazon and Tocantins-Araguaia hydrographic basins, located in the North of the country (EPE, 2020), which is the new frontier of hydropower generation projects.

Looking back at the period before Chinese electric firms arrived in Brazil, the prospects of investments in hydropower were no different. According to the Energy National Plan 2030, launched in 2006, Brazil was the nation with the biggest potential in the world – 260 GW –, of which only 30 percent was exploited. The Plan established the target of making use of 126 GW in the coming years (EPE, 2006).

Prospects for investments in the Brazilian wind sector are non-negligible. In 2019, Brazil's wind installed capacity reached 15.4 GW, around 9 percent of the total capacity in operation, dispersed among 629 plants (Aneel, 2020). It ranked seventh in the world, ahead of other traditional clean energy investors, such as UK and Canada (GWEC, 2020 p. 27). Imposingly, there was a remarkable growth of wind generation capacity in just ten years, since the first technology-specific auctioned took place in 2009 and the source utilization took off.

The reasons for such an impressive growth have relations with the country's local conditions. Brazil has a capacity factor above the world average. In 2019, it was on average 42.7 percent, whereas in other nations it rarely surpasses 40 percent, ranging around 25 percent (Gorini, 2018). In some Northern states, the factor stays above 70 percent in several months of the year, guaranteeing high productivity of the local wind farms. Furthermore, wind speed volatility is low, around 5 percent, giving more predictability about the volume of energy to be generated. Besides, because the speed is usually higher in times of drought, when hydropower dams operates in low capacity, wind is a reliable complement to hydro generation (Aneel, 2008 p. 81) (EPE, 2018).

Because of these favorable conditions and the constant improvement of applied technology over the years, Brazil's wind potential has substantially expanded. Older estimates have predicted a wind generation potential of 143 GW (Cresesb, 2001). More recent assessments foresee that this number could reach as high as 880 GW, of which 522 GW would be feasible to explore onshore (Freire, 2016). Considering heights from 80 to 100 meters, wind resources could be over 350 GW (Husar, et al., 2013 p. 19).

Brazil is also favorably endowed with solar radiation. As of 2019, installed solar capacity was still only a small portion of the total, less than 2 percent, considering plants in operation[34]. Nonetheless, considering that large-scale investments in this source of energy are more recent than wind, the growth has been impressive. In 2010, its share was close to 0 percent (Aneel, 2020) and, considering plants currently under construction, the percentage of solar will grow to almost 7 percent in the next few years (Aneel, 2020). This is facilitated by the fact that solar farms are easier and faster to build than hydropower dams.

This performance is also facilitated by local privileged natural conditions. Brazil's solar radiation varies in between 1,500 and 2,350 kWh/m2/year and it is well distributed over the country. These figures are superior to other traditional clean energy producers, such as Germany (900 to 1,250 kWh/m2/year), France (900 to 1,650) and Spain (1,200 to 1,850) (Sebrae, 2017 p. 43). In the least sunny spot in Brazil, it is possible to generate more solar energy than in the sunniest place in Germany (Pereira, et al., 2017 p. 57). Northern regions, for instance, have numbers comparable to world's top places, such as Dongola, in Sudan's desert, and Dagget, at the Mojave Desert, in California (Aneel, 2008 p. 85). Under these circumstances, according to the Brazilian Association of Solar Energy (ABSolar), a conservative estimation of Brazil's solar power potential would be 28,500 GWp, more than any other source of energy in the country (Sebrae, 2017 p. 45). For the Solar and Wind Energy Resource Assessment (SWERA) Program, Brazil ranks fifth in the world in terms of solar potential (Apex, 2020).

Advantageous market conditions

When Chinese electric firms started to turn their eyes towards Brazil, they have encountered two concomitant advantageous factors. On the one hand, there was the long-term fact that Brazil's energy sector is market-oriented, stable and with a strong regulatory system, favorable to the arrival of new players, foreigners or not. On the other hand, when the country was momentarily undergoing a political-economic crisis, several electric assets all of a sudden became business opportunities to deep-pocket companies willing to establish a lasting presence in the local market.

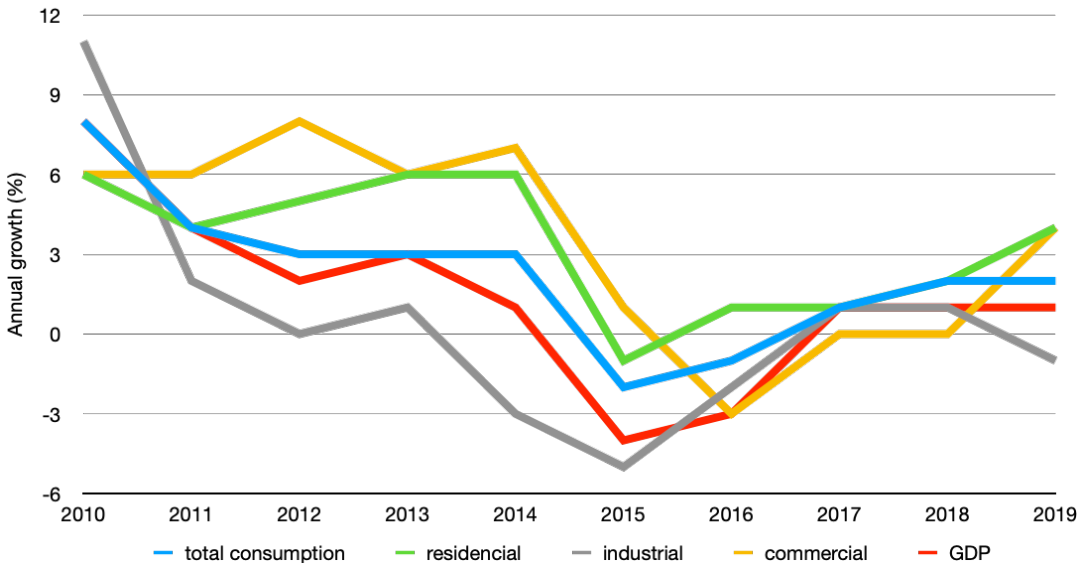
LONG-TERM FACTORS

In short, four features of Brazil's electricity system seemed to attract Chinese energy companies to invest there, namely (i) domestic demand, (ii) legal and regulatory system, (iii) tariff rates, and (iv) profit margins.

Brazilian domestic demand has continuously expanded over time. The country's nearly 210 million citizens altogether represent the eight biggest consumer market in the world, not to mention that Brazil was the ninth largest economy (WorldBank, 2020) and the sixth largest FDI destination in 2019 (Unctad, 2020). According to data from the U.S. Energy Information Administration (EIA), among the top ten biggest electric consumers in the world, Brazil's demand expanded 23 percent between 2008 and 2017, the fourth fastest in the world (EIA, 2020).

[34] Only centralized solar PV generation units are considered here, which are integrated in the national electric system.

Figure 28: Electricity consumption and GDP real growth per year (percent)



Source: EPE and IBGE.

Between 2010 and 2019, Brazil's electricity consumption has grown in a faster rhythm than the country's GDP, with the sole exception of 2017 (EPE, 2020). Even in periods of economic downturn, such as in 2015 and 2016, when the Brazilian economy contracted almost 7 percent, energy demand decreased comparatively less. This was thanks to residential demand, which has kept a steady growth over the period. In contrast, industrial and commercial consumptions, which historically accounted for more than half of the total, followed closely the ups and downs of the economic activities.

Due to the upward tendency in electric consumption growth in Brazil, the International Energy Agency (IEA), in a 2013 report, not surprisingly highlighted Brazil's consumption growth as a decisive factor for attracting Chinese investments. (Husar, et al., 2013 p. 17). In 2016, in a media interview, Li Yinsheng, CTG's head in Brazil, affirmed that expected growth in power demand in the country justifies the investments already made and planned for the future (Costa, 2016).

Coupled with the steady growth of domestic demand, Brazil's strong regulatory system is another positive point. The electricity sector is essentially technology and capital intensive and operates under a long-term horizon for repayment of the capital invested. Huge amounts of money are disbursed in the initial steps of the project – construction –, but operation and maintenance costs are relatively low, and earnings before interest, taxes, depreciation and amortization are normally high. However, this calculation is only assured if market and contract conditions are stable over time. Therefore, a sound, transparent and strong regulatory system is mandatory, so as to attract new players to invest. In this sense, the Brazilian electricity regulatory system is highly praised for its legal and institutional stability. Aneel is the governmental agency responsible for organizing public auctions and overseeing compliance with the law and contracts.

During interviews with employees and managers from Chinese electric companies in Brazil, this topic was unanimously raised. Some interviewees emphasized that their firms' experience in Brazil contrasts with other places, where norms are not clear and the implementation of contracts is sometimes based on political and inter-personal connections (Anonymous1, 2020). In Brazil, contracts are rightfully implemented over the years and the system has a market-oriented perspective,

in which free competition among players is stimulated as a tool to decrease costs and increase overall efficiency (Anonymous2, 2020). Furthermore, no political restrictions on foreign actors are imposed; once locally established, they receive the same treatment (Anonymous5, 2020). Instead, there is a government-backed active policy to attract foreign investors to the energy sector, either in the form of M&A or direct participation in auctions (Anonymous3, 2020).

Moreover, the existence of qualified technical personnel is another attractive factor. Contrary to other emerging economies, in which the lack of skilled local work force limits investments or obliges the hiring of technicians from China, in Brazil, except highly managerial positions, such as CEO, most of the staff is local. Lastly, Brazil is free from large-scale theft of electricity and there are constant efforts to combat them (Anonymous1, 2020).

Tariff rates are undeniably a determinant component for investments. Brazilian retail electricity prices jumped approximately 81 percent from 2010 to 2018, in the three main customer classes, namely commercial, industrial and residential (Climatescope, 2020). In a broader range of time, rates increased 751.7 percent between 1995 and 2015, with a peak in the last two years[35]. In comparison, the official inflation (IPCA index) reached accumulative average of 342 percent in the same period (Dieese, 2017 p. 12).

The way tariffs are calculated in Brazil also matters. According to Castro et al (2017), under a market-oriented logic, rates are determined according to a delicate balance between the affordability of prices for consumers and the necessity of recouping the capital invested by concessionaires. Therefore, tariff calculation is bottom-up, in which the cost of production is taken into careful consideration. This model contrasts with other countries' approach. In Russia and China, for instance, the mode of decision is historically top-down, fares are strictly controlled or subsidized.[36] Local authorities also keep the tariffs low and force their companies – mainly state-owned – to adjust their internal expenditures or to flatten profit margins (Castro, et al., 2017 p. 71).

In their study, Castro et al (2017) make a comparison between the value and the composition of electricity tariffs among a broad group of nations, from 2009 and 2013, and provided interesting findings. Although Brazilian residential rates have decreased in this period, they were kept above the global average, being as high as European countries, whose fares are normally the highest in the world (Castro, et al., 2017 p. 54). Similar to these states, elevated taxes are one of the main reasons for high tariffs. In Brazil, governmental duties represented 36 percent of the final electricity price (Castro, et al., 2017 p. 55).

This situation has enormous differences with the Chinese one. Over the same period, China's residential fares have showed almost no oscillation, and were three times lower than in Brazil. Chinese consumers also paid less taxes, which was on average 19 percent of the final price. Costs of generation and network maintenance were another differential feature. In 2013, in China, they were altogether less than half of that in Brazil (Castro, et al., 2017 p. 57).

Last but not least, higher tariffs also meant higher return margins to concessionaires. One of the declared reasons of Chinese firms' internationalization is the expectation of large profits. In the particular case of Chinese electricity firms, this point is even more relevant, since, as discussed, the logic of remunerating the capital invested with rates compatible with those commonly applied in the market is not prevalent there. The electric state-owned enterprises are all part of a conscious effort to keep overall rates low, benefiting final consumers (Castro, et al., 2017 p. 19). Under these

[35] In 2014-2015, Brazil experienced a severe drought in the country, which substantially decreased the reservoir level of its hydropower dams. As an alternative, the government resorted to thermoelectric plants, mainly based on oil, whose costs are higher than renewables. As a result, electricity prices jumped 300 percent in those two years.

[36] China's 2020 electricity market reform has changed this scenario.

circumstances, overseas expansion is a more than desirable escape valve to a less profitable Chinese electric sector (Husar, et al., 2013 p. 17).

The exact rate of return of each company's investment is difficult to measure. Business practices, commercial strategy, corporate confidentiality and project's specificities are among the reasons. Nonetheless, one can resort to two mechanisms to deduce the profit margins: comments from companies' directors and the WACC index.

After successfully bidding for the Phase I of the Belo Monte transmission lines, the President of Eletrobras have commented that the rate of return would be one digit, but very close to 10 percent (Collet, et al., 2014). In an article about the project, Cui Shoujun (2019) affirms that the rate of return on investment Phase II would be over 14 percent (Cui, et al., 2019 p. 247). In the same direction went remarks made by a member of Eletrobras' administrative council, Jose Luiz Alqueres. According to him, annual net profit margins of the electric sector as a whole are between 6 percent and 10 percent (Rockmann, 2019). The same information was confirmed during interview made by the author. In wind projects in Northeastern Brazil, for instance, generators usually obtain profit margins between 9.5 percent and 12 percent (Anonymous4, 2020). Lastly, Cote (2014) quoted a State Grid's employee saying that the firm only invests abroad in case of return rates two to three times bigger than similar projects in China (Cote, 2014 p. 22).

WACC is the weighted average cost of capital, which is, *grosso modo*, exchangeable for the firm's cost of capital. In simple terms, it is the company's earnings before interest and taxes[37]. Aneel makes use of this methodology to evaluate the estimated investments in each project. This calculation influences the determination of tariffs and the minimum bidding prices – or maximum revenue per year, in the case of transmission – in auctions.

There are specific WACC per segment and, as a common trait, their value has been decreasing over time, according to periodic reviews coordinated by Aneel. In the generation sector, the WACC was 7.16 percent in 2014 and declined to 6.96 percent in early 2020. In transmission, it was 9.18 percent in 2007, dropped to 6.64 percent in 2013 and increased to 6.96 percent in 2020. In distribution, it was 11.26 percent in 2003, diminished to 7.50 percent in 2011 and further to 7.32 percent in the beginning of 2020 (Aneel, 2020). These fluctuations reflect changes in the risk of investment over time, for example, a new macroeconomic scenario, alterations of investors' expectations, of the cost and risk of credit etc. (Oliveira, et al., 2018 p. 48).

SHORT-TERM FACTORS

Another set of reasons that help to explain Chinese electricity firms' investment push in Brazil are related to the country's experienced temporary unstable political, economic and financial situation and some legal changes that generated matchless business opportunities for new-comers willing to invest in large-scale infrastructure projects.

The 2008 financial crisis might be regarded as the onset of substantial changes in Brazil's electricity sector. A considerable number of already locally established subsidiaries started to suffer from the deteriorating financial condition in their European and North American headquarters and of the overall debt crisis and liquidity shortage. In contrast, Chinese electricity firms that were on the early stages of their international expansion grabbed the opportunity.

Examples of this phenomenon abound. In 2010, the Spanish firms Elecnor, Isolux and Cobra sold seven local transmission concessionaires to State Grid, which then officially arrived in the country. In 2011, the indebted Portuguese government decided to privatize EDP, allowing CTG to disembark

[37] For further technical information about WACC, please refer to Oliveira et al (Oliveira, et al., 2018 p. 47).

in Brazil. In 2012, the also Spanish ACS Group decided to disinvest part of its assets in Brazil in response to the impacts of the crisis in its balance sheets and transferred them to State Grid.

The negative effects of the 2008 financial crash were aggravated over time with deteriorating macroeconomic conditions in Brazil, particularly from 2013 on. The end of the commodities super cycle helped to trigger this process. The country's GDP growth declined substantially from 2010 to 2016 – except in 2012 – and saw negative rates in 2009, 2015 and 2016. Indeed, these last two year represented the worst recession in decades (WorldBank, 2020).

This process was aggravated by the outbreak of a corruption scandal in 2014 that has dragged major energy firms in a continuous downturn of events. With debts skyrocketing, shares in the stock exchange melting, and facing legal and administrative punitive measures inside and outside the country, national giants such as Petrobras, Camargo Correa, Andrade Gutierrez, Queiroz Galvao, OAS, and other heavy civil constructors, which were shareholders in relevant electricity assets, all of a sudden started to discontinue large infrastructure investments and put some on sale (Becard, et al., 2020 p. 62). One example is CPFL, in which Camargo Correa was a relevant stakeholder.

Collaterally, Brazilian currency Real has experienced constant devaluation over the years, making local assets look even more attractive to foreign opportunity-seeker's eyes. Between 2008 and 2019, the Real devaluated around 115 percent against the US dollar (Investing.com, 2020), giving the chance to foreign investors to purchase strategic resources at a cheaper price.

In the wake of these developments, the overall financial situation of the federal and state administrations has impacted the electric sector as well. Budgetary constraints and fiscal and monetary policies' adjustments have impeded government investments. State-owned corporations were not exempt. BNDES, the financial backbone of infrastructure projects in the country, has shrunk its loan disbursements and credit facilities. More recently, the institution has changed the methodology of calculating long-term interest rates, bringing them closer to local commercial ones[38].

Concomitant to these events, some legal changes and policy decisions also helped to attract Chinese electric firms. In 2013, a novel regulation[39] linked the possibility of automatic renewal of concessions in the generation, transmission and distribution sectors that would expire in 2017 to sizeable reductions in tariffs, which would become 20 percent lower on average (Becard, et al., 2020 p. 62) (Oliveira, et al., 2018 p. 8). The new terms were not accepted by some provincial-owned firms, such as Cemig, Cesp, Copel, and Celesc, whose assets were auctioned in the following years and ended up in foreign hands (Dieese, 2015 p. 7). For example, Ilha Solteira and Jupia dams previously belonged to Cesp and were bought by CTG in 2015. Sao Simao dam, which was acquired by SPIC and other Chinese firms and funds in 2017, was formerly a Cemig's asset.

Lastly, due to the fact that these Chinese state-owned corporations have grasped the opportunities brought by the abovementioned long-term and short-term factors, some studies described this

[38] Oliveira et al (2018) elaborate more on the different financing costs in Brazil and abroad as an explanatory factor for the successful participation of foreign companies, especially state-owned ones, in Aneel's bids. They argue that the countries these firms come from have lower interest and country risk rates, cheapening the access to credit, either in the form of loans or of bond emissions, such as debenture (Oliveira, et al., 2018 p. 11). Subsidies are still a common tool, particularly for SOE (Oliveira, et al., 2018 p. 58). They highlight that, since all participants in biddings are technically qualified to offer the service in more or less equal terms, the distinguished advantage lies in offering lower prices, accepting lower WACC, in whose composition the financing cost has a heavy weight. The cost of capital is of utmost importance in a capital-intensive sector (Oliveira, et al., 2018 p. 55). They affirm that this whole situation creates an unfair competition, since national and international players cannot compete in isonomic terms (Oliveira, et al., 2018 p. 59). Thus, they call for a broad, open and strategic debate on these issues and on the adequacy of the current legal framework, in which creates a natural monopoly in the transmission and distribution segments, which have now great participation of foreign and state-owned actors (Oliveira, et al., 2018 p. 6).

[39] For further information, see Provisional Measure n. 579, of September 11, 2012, and Law n. 12.783, of January 11, 2013.

phenomenon as privatization followed by nationalization, yet this time, instead, in the hands of foreign governments (Dieese, 2017 p. 15).

CONCLUSION AND FUTURE TRENDS

This work's inception came from the identified necessity to fill a literature gap on the magnitude and evolution of Chinese investments, construction projects, and financing activities in Brazil`s electricity sector over the last two decades. Several studies about Chinese electricity firms and banks' worldwide expansion have emerged recently, yet bilateral investigations are still scarce. It is not different with Brazil-China. The growing number of academic papers and institutional reports on the topic has not yet satisfied the need to understand how deep Chinese players have penetrated in the Brazilian electricity sector and how fast this phenomenon has evolved. With this aim in mind, out of the global "book" of Chinese electric activities around the world, this article tries to write a comprehensive but not superficial "Brazilian chapter".

This paper provides the first estimates of Chinese firms' installed capacity, length of transmission lines, and number of consumer units under their coverage. Brazil's electricity sector has been undergoing a continuous internationalization process over the last two decades, with foreign players speeding up investments in the South American country. After 2010, this phenomenon has gained vigor with the arrival of a new player: China. Chinese actors were the ones that more aggressively expanded its assets in generation, transmission, and distribution sectors, at the expense of other foreign firms, but mainly Brazilian ones. After ten years, through 2019, they possessed a total of 16,736 MW, 16,776 km of lines and 126 million consumer units, or roughly 10 percent, 12 percent and 12 percent of each segment respectively. This expansion has given them a higher position: they have achieved the second, third and fourth places in terms of nationalities` percentage of the generation, transmission, and distribution sectors.

Power generation, transmission and distribution are essential parts of any country's energy security and socioeconomic development strategy and, thus, are strictly planned and uninterruptedly monitored by governments and regulators. Brazil is not an exception. The country implements rigorous technical, managerial, environmental and market regulations, so as to maintain the continuous flow of electricity from power plants to local residents and industries in the short, middle and long terms and under the best technological, price and cost conditions. Chinese electricity firms in Brazil, like any other foreign and domestic players, operates under this scenario.

This setting has generated benefits for both sides. On the one hand, Chinese actors have taken advantage of a stable and controlled business setting, in which contracts are respected and meticulously implemented in the long run. On the other hand, the Brazilian government and society were in need and have benefited from external players bringing technology, managerial expertise, financial resources, and a long-lasting commitment to invest in the country. Chinese players have helped to solve local electricity bottlenecks and to foster investments in all three segments.

Given the present conditions, future expectations indicate an expansion of Chinese electricity companies' investments and assets in Brazil, in the coming years. In this process, complementarity might continue to be the defining feature.

On the one hand, the Brazilian government has plans to keep enlarging its national installed capacity, so as to meet rising consumption, which will probably increase 50 percent between 2020 and 2029 (EPE, 2016 p. 154). In the same period, 67.9 GW will be added to the system, with wind power responsible for more than one-third of this growth (EPE, 2020 p. 282). This expansion will require

US$113 billion in generation and transmission investments (EPE, 2020 p. 286)[40]. On the other hand, the financial might, investment capacity, and technological prowess of China's electric firms provide "ingredients" to predict their continuous overseas development (Cabré, et al., 2018 p. 47).

Wind and solar power might be possible hotspots to receive future Chinese investments. In the next decades, the world will move towards clean energy projects and to a greater participation of these two sources (BloombergNEF, 2020), mainly due to their declining production costs and environmental benefits (Kong, et al., 2020 p. 13). Most of Brazil's power generation projects under construction at the end of 2019 or to be constructed are already solar, wind, and small hydropower stations (Aneel, 2020).

One of the intended positive externalities of this work is to provide a broad and thorough portrait of the Chinese presence in Brazil's electricity sector, of how deep China has penetrated in each of the segments. This picture might have multiple uses. It can be useful for sectoral researches or geographic analyses on a state, local or project level. It may be valuable to business entrepreneurs endeavoring to enter or expand assets in the Brazilian market. It might be a valuable device for policy and decision-makers from both sides, who constantly need to craft development strategies for their countries. Ultimately, but not less important, it can serve as a contribution to the ongoing process of increasing mutual understanding and awareness of the relevance of the Sino-Brazilian relations, either in the electricity sector or in many others.

METHODOLOGY

This work has resorted to a wide range of sources, according to the necessities presented in each section.

To identify investment numbers and projects, either FDI or services, databases and reports such as "China-Latin America Economic Bulletin" from Boston University's Global Development Policy Center (GDPC); "Chinese Investments in Brazil" from the China-Brazil Business Council; "Foreign Investment Bulletin – Selected Countries" from the Brazilian Ministry of Economy; "Monitor of Chinese OFDI in Latin America and the Caribbean" and "Monitor of Chinese Infrastructure in Latin America and the Caribbean" from the Center for Chinese-Mexican Studies (Cechimex); "China Global Investment Tracker" from the American Enterprise Institute; and FDI Intelligence from the Financial Times and the DeaLogic database were valuable sources for project lists and capital invested, especially in M&A. Company's financial statements and media reports were also used.

For power generation, transmission and distribution assets' tracking, "China's Global Power Database" from GDPC and chiefly Brazilian Electricity Regulatory Agency's (Aneel) official materials were important to calculate Chinese firms' possessions in Brazil and in the globe. Aneel's documents provided detailed and reliable information about greenfield investments.[41]

For engineering and manufacturing activities, media accounts and company's statements were the main sources.

For Chinese loans, "China's Global Energy Finance Database" from GDPC, "Global Chinese Official Finance Dataset", from Aid Data, "Chinese Development Finance in LAC", jointly supported by the

[40] The amount in Brazilian currency is R$ 456 billion. The exchange rate used was of January 1st, 2020.

[41] The published studies and reports from Aneel are not commonly cited as a source, probably due to the fact that the detailed information about specific projects, such as generation capacity, length of transmission lines, location, estimated capital, companies involved, R&D figures etc. are all dispersed and disaggregated in a myriad of essentially technical papers and legal documents, whose reading and interpretation are not easy tasks for outsiders and non-specialized readers. Another barrier might be the language, since the majority of the data is in Portuguese.

Inter-American Dialogue and the GDPC, as well as companies' financial accounts and media reports were very useful tools. From the statements of Brazilian development banks, such as the National Bank for Economic and Social Development (BNDES) and the Northeast Bank of Brazil (BNB), a lot of information was extracted.

To calculate the disbursed capital in each project, some methodological criteria were adopted. Greenfield ventures' numbers in generation and transmission come mainly from Aneel, which estimates the amount of capital each concessionaire has to invest. Aneel's bidding notice usually requires a minimum deposit of 1 percent of the total planned investment, which is then inferred from this guarantee deposit. This total investment is included in the year of the projects' auction.

All values are shown in US dollars, unless otherwise specified. The exchange rate used is that of the date of the announcement of the deal or of the result of the bidding process. For transmission line projects that cross more than one state in Brazil, the amount of money invested is divided equally by the number of states involved, so as to have a picture of how much was invested in each state. Investments that involved different sectors – usually the acquisition of existing companies through M&A – were included only in the generation segment, since concessionaires that operate in multiple segments usually have most of their investments in generation. Only confirmed projects are considered; announced investments are discussed, but their values are not included in the overall estimation.

In addition, Chinese investment numbers in each project reflect the Chinese firms' share of the enterprise and not the total amount spent by the consortium in which they participate. In new transmission line projects specifically, the discount offered by the winning company or consortium during bids was taken into consideration. For example, all numbers of CTG investments used here that are related to EDP's companies in Brazil are calculated according to the Chinese firm's shares in the Portuguese corporation.

The total of MW attributed to each Chinese company here reflects this firm's participation in the consortium or concessionaire, whose ownership structure is provided by Aneel (Aneel, 2020). Projects under construction or to be constructed – already auctioned – are included here. The same logic is applied for Chinese corporations in the distribution segment, in which the number of consumer units is taken as a reference. For yearly analysis, the total installed capacity of any new plant is counted in the year of the auction, not in the operations' start date.

The length of transmission lines is that estimated by Aneel in each bidding notice. It is reported that the actual dimension of the finished line is slightly distinct, but the changes are minor and are not disposed in a consolidated way. Differently to generation, in the transmission part, the kilometers of lines that are attributed to Chinese actors are not calculated according to the company's share of the consortium. If the Chinese player has the controlling stake of the investment group, the total line is considered Chinese.

An important note is that the data available by Aneel does not encompass the totality of the Brazilian power grid. For instance, in the list of auctions, there are only information about 102,000 km of lines (Aneel, 2020), whereas the total national extension in the end of 2019 was 141,000 km. According to explanations obtained in interviews with technical personnel from the Agency, this difference refers mainly to old transmission lines, mostly owned by Eletrobras and subsidiaries before the 2000's, since when data is compiled in the list of auctions (Anonymous2, 2020). Therefore, any difference or missing data can be regarded as belonging to Eletrobras.

For the sake of identifying the nationalities behind each concessionaire, the following information was checked: investing companies, their nationality/origin, ownership percentage of the plant and

installed capacity. The nationality is determined according to the address registered at Aneel. Only plants in operation were analyzed. Aneel provides data about the ownership structure of concessionaires in the generation (Aneel, 2020), transmission and distribution sectors (Aneel, 2020). For the last two, information is on a yearly basis, making it easier to track M&A over time. This functionality does not exist for power plants, making it necessary to check each project contracts and amendments (Aneel, 2020).

Last but not least, due to these difficulties in obtaining precise information and the necessity to resort to different sources sometimes, the numbers presented in this study must be regarded as an estimation.

ACKNOWLEDGEMENTS

The present article was written under the supervision of professors Kevin Gallagher and Rebecca Ray, during the author's participation in the Global China Initiative Fellowship Program 2020, at Boston University`s Global Development Policy Center (GDPC).

The author is immensely grateful for Ma Xinyue's comments and Kamila Alencar's research assistance.

The opinions expressed here are personal and do not necessarily reflect those of the institutions the author is affiliated to.

BIBLIOGRAPHY

ABDI. 2014. Atualização do Mapeamento da Cadeia Produtiva da Indústria Eólica no Brasil. [Online] 2014. [Cited: 5 5, 2020.] http://inteligencia.abdi.com.br/wp-content/uploads/2017/08/2018-08-07_ABDI_relatorio_6-1_atualizacao-do-mapeamento-da-cadeia-produtiva-da-industria-eolica-no-brasil-WEB.pdf.

Aben. 2017. Eletrobras e China National Nuclear Corporation assinam memorando de entendimento. *Associação Brasileira de Energia Nuclear.* [Online] 8 28, 2017. [Cited: 5 5, 2020.] http://www.aben.com.br/noticias/eletrobras-e-china-national-nuclear-corporation-assinam-memorando-de-entendimento.

AgoraRN. 2019. Vinda de chineses reanima projeto de fábrica de placas fotovoltaicas. [Online] 8 8, 2019. [Cited: 5 5, 2020.] https://agorarn.com.br/economia/vinda-de-chineses-reanima-projeto-de-fabrica-de-placas-fotovoltaicas/.

Alves, Sabrina. 2018. Prefeitura avança dialogo para a instalação de empresa chinesa. [Online] 9 13, 2018. [Cited: 5 5, 2020.] http://www.uberaba.mg.gov.br/portal/conteudo,44794.

Aneel. 2015. Aneel 007/2015 - Licitacao na modalidade de leilao para a contratacao de servico publico de transmissao de energia eletrica. *Aneel.* [Online] 7 17, 2015. [Cited: 5 5, 2020.] http://www2.aneel.gov.br/aplicacoes/editais_transmissao/documentos/Resultado_leilao_07-2015.pdf.

—. 2015. Aneel aprova compra de duas transmissoras pela State Grid. [Online] 1 23, 2015. [Cited: 5 5, 2020.] https://valor.globo.com/empresas/noticia/2015/01/23/aneel-aprova-compra-de-duas-transmissoras-pela-state-grid.ghtml.

—. 2018. Aneel recomenda ao MME caducidade do Contrato de Concessão nº 001/2015. [Online] 9 28, 2018. [Cited: 5 5, 2020.] https://www.aneel.gov.br/web/guest/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVlZ6/content/id/17420018.

—. 2008. Atlas de energia elétrica do Brasil. [Online] 2008. [Cited: 5 5, 2020.] http://www2.aneel.gov.br/arquivos/pdf/atlas3ed.pdf.

—. 2020. Composicao societaria de distribuicao. *SRM.* [Online] 5 25, 2020. [Cited: 5 25, 2020.] https://app.powerbi.com/view?r=eyJrIjoiNDFmY2U1ODgtNjkyYy00OWI5LWJhOGItNmIyNDhmY2NmYjdjIiwidCI6IjQwZDZmOWI4LWVjYTctNDZhMi05MmQ0LWVhNGU5YzAxNzBlMSIsImMiOjR9.

—. 2012. Consórcio Guaraciaba arremata Lote B. [Online] 3 9, 2012. [Cited: 5 5, 2020.] https://www.aneel.gov.br/web/guest/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVIZ6/content/id/14491719.

—. 2011. Consórcio Luziânia-Niquelândia arremata lote H. [Online] 12 16, 2011. [Cited: 5 5, 2020.] https://www.aneel.gov.br/web/guest/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVIZ6/content/id/14556172.

—. 2012. Consórcio Sino-Copeliano vence Lote A do Leilão de Transmissão nº 02/2012. [Online] 3 9, 2012. [Cited: 5 5, 2020.] https://www.aneel.gov.br/web/guest/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVIZ6/content/id/14552490.

—. 2020. Contratos de Geração. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.aneel.gov.br/contratos-de-geracao?p_p_id=contratos_WAR_contratosdeconcessaoportlet_INSTANCE_uu1kOqDwaANI&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_count=2.

—. 2020. E-SIC. [Online] 2020. https://esic.cgu.gov.br/sistema/site/index.aspx?ReturnUrl=%2fsistema%2fprincipal.aspx.

—. 2017. Hidrelétrica São Simão é arrematada pela chinesa SPIC Pacific Energy. *Aneel.* [Online] 11 27, 2017. [Cited: 5 5, 2020.] http://www.aneel.gov.br/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVIZ6/content/hidreletrica-sao-simao-e-arrematada-pela-chinesa-spic-pacific-energy/656877?inheritRedirect=false.

—. 2014. Leilão da transmissão de Belo Monte alcança 38 percent de deságio. [Online] 2 7, 2014. [Cited: 5 5, 2020.] http://www2.aneel.gov.br/aplicacoes/noticias/Output_Noticias.cfm?Identidade=7741&id_area=90.

—. 2020. Leiloes de transmissao. [Online] 5 25, 2020. [Cited: 5 25, 2020.] https://www.aneel.gov.br/transmissao4.

—. 2015. Lote E abre leilão com sucesso para as usinas de Jupiá e Ilha Solteira. *Aneel.* [Online] 11 25, 2015. [Cited: 5 5, 2020.] https://www.aneel.gov.br/web/guest/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVIZ6/content/id/14617302.

—. 2020. Participacao Acionaria dos Proprietarios dos Empreendimentos. *Paracemp.* [Online] 5 25, 2020. [Cited: 5 25, 2020.] http://www2.aneel.gov.br/paracemp/apl/PARACEMP_Menu.asp.

—. 2020. Pesquisa & Desenvolvimento. *Aneel.* [Online] 2020. [Cited: 5 5, 2020.] https://www2.aneel.gov.br/area.cfm?idArea=722&idPerfil=3.

—. 2020. RelSampRankUC. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://relatorios.aneel.gov.br/_layouts/xlviewer.aspx?id=/RelatoriosSAS/RelSampRankUC.xlsx&Source=http://relatorios.aneel.gov.br/RelatoriosSAS/Forms/AllItems.aspx&DefaultItemOpen=http://relatorios.aneel.gov.br/_layouts/xlviewer.aspx?id=/RelatoriosSAS/RelS.

—. 2020. Resultados de Leilões. [Online] 4 8, 2020. [Cited: 5 5, 2020.] https://www.aneel.gov.br/resultados-de-leiloes.

—. 2020. Resultados de Leilões. [Online] 4 8, 2020. [Cited: 5 5, 202.] https://www.aneel.gov.br/resultados-de-leiloes.

—. 2020. Sistema de Informações de Geração da ANEEL. *Aneel.* [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.aneel.gov.br/siga.

—. 2020. Usinas Geradoras. [Online] 1 1, 2020. [Cited: 5 5, 2020.] http://www.dados.gov.br/dataset/usinas-geradoras.

Anonymous1. 2020. *CTG.* [interv.] Pedro Barbosa. 5 5, 2020.

Anonymous2. 2020. *Aneel.* [interv.] Pedro Barbosa. 5 1, 2020.

Anonymous3. 2020. *Ministry of Foreign Affairs.* [interv.] Pedro Barbosa. 5 22, 2020.

Anonymous4. 2020. *Government of Pernambuco.* [interv.] Pedro Barbosa. 5 1, 2020.

Anonymous5. 2020. *Ministry of Mines and Energy.* [interv.] Pedro Barbosa. 5 19, 2020.

Apex. 2017. BYD inaugura fabrica de paineis solares em Campinas. *Apex.* [Online] 4 6, 2017. [Cited: 5 5, 2020.] https://portal.apexbrasil.com.br/noticia/BYD-INAUGURA-FABRICA-DE-PAINEIS-SOLARES-EM-CAMPINAS/.

—. 2020. Setores Prioritários. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://portal.apexbrasil.com.br/setores-prioritarios/.

Araujo, Luzia. 2018. China investirá US$330 milhões para produção de energia solar em MT. [Online] 1 31, 2018. [Cited: 5 5, 2020.] http://www.mt.gov.br/rss/-/asset_publisher/Hf4xlehM0Iwr/content/id/9220918.

Barbosa, Alexandre, Tepassê, Ângela and Biancalana, Marina. 2014. Las relaciones económicas entre Brasil y China a partir del desempeño de las empresas State Grid y Lenovo. [book auth.] Enrique Peters. *La inversión extranjera directa de China en América Latina: 10 estudios de caso.* Mexico City : Unam, 2014, pp. 61-132.

Barbosa, Pedro. 2020. Chines Economic Statecraft and Brazil-China Oil Finance Cooperation. 2020. To be published.

Bautzer, Tatiana. 2017. Brazil's Cemig says China's State Power Investment bids for stake in dam. *Reuters.* [Online] 6 27, 2017. [Cited: 5 5, 202.] https://www.reuters.com/article/us-cemig-divestiture/brazils-cemig-says-chinas-state-power-investment-bids-for-stake-in-dam-idUSKBN19I31G.

Becard, Danielly and Macedo, Bruno. 2014. Chinese multinational corporations in Brazil: strategies and implications in energy and telecom sectors. *RBPI.* 2014, Vol. 1, 57, pp. 143-161.

Becard, Danielly, Lessa, Antonio and Silveira, Laura. 2020. One Step Closer: The Politics and the Economics of China's Strategy in Brazil and the Case of the Electric Power Sector. [book auth.] Raul Bernal-Meza and Li Xing. *China–Latin America Relations in the 21st Century: The Dual Complexities of Opportunities and Challenges.* Boston : Palgrave MacMillan, 2020, pp. 55-82.

Bellini, Emiliano. 2018. Astronergy fornece os módulos para o projeto de 90 MW no Ceará. *PV Magazine.* [Online] 1 5, 2018. [Cited: 5 5, 2020.] https://www.pv-magazine-latam.com/brasil-noticias/astronergy-fornece-os-modulos-para-o-projeto-de-90-mw-no-ceara/.

—. 2019. Canadian Solar se asegura $80 millones para proyecto FV con paneles bifaciales en Brasil. [Online] 1 31, 2019. [Cited: 5 5, 2020.] https://www.pv-magazine-latam.com/2019/01/31/canadian-solar-se-asegura-80-millones-para-proyecto-fv-con-paneles-bifaciales-en-brasil/.

—. 2018. Canadian Solar y EDF se aseguran financiación para un proyecto FV de 399 MW en Brasil. [Online] 11 26, 2018. [Cited: 5 5, 2020.] https://www.pv-magazine-latam.com/2018/11/26/canadian-solar-y-edf-se-aseguran-financiacion-para-un-proyecto-fv-de-399-mw-en-brasil/.

BloombergNEF. 2020. Climatescope 2019. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://global-climatescope.org/results/BR.

—. 2020. New Energy Outlook 2019. [Online] 1 1, 2020. [Cited: 5 5, 2020.] https://about.bnef.com/new-energy-outlook/#toc-download.

BMTE. 2014. Demonstracoes financeiras. [Online] 12 31, 2014. [Cited: 5 5, 2020.] http://www.bmte.com.br/wp-content/uploads/2018/12/111382-BMTE-Dezembro-2014-V16_CLIENTE.pdf.

—. 2015. Demonstracoes financeiras. [Online] 12 31, 2015. [Cited: 5 5, 2020.] http://www.bmte.com.br/wp-content/uploads/2019/03/Exercicio-2015-KPMG.pdf.

—. 2016. Demonstracoes financeiras. [Online] 12 31, 2016. [Cited: 5 5, 2020.] http://www.bmte.com.br/wp-content/uploads/2017/02/DFs-Auditadas-2016-com-todas-as-assinaturas-4.pdf.

—. 2014. Relatório de Impacto Ambiental da Linha de Transmissão CC ±800 kV Xingu / Estreito. [Online] 12 1, 2014. [Cited: 5 5, 2020.] http://www.bmte.com.br/wp-content/uploads/2016/06/RIMA.pdf.

BNB. 2020. BNB Transparente: Consulta Operações de Crédito por Cliente. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.bnb.gov.br/bnb-transparente/operacoes-de-credito-por-cliente.

BNDES. 2017. BNDES aprova R$ 2,56 bilhões para sistema de transmissão da Usina Hidrelétrica Belo Monte. [Online] 2 20, 2017. [Cited: 5 5, 2020.] https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/bndes-aprova-2-bi-para-belo-monte.

—. 2018. BNDES aprova R$ 5,2 bilhões para linha de transmissão de UHE Belo Monte (PA) ao RJ. [Online] 11 19, 2018. [Cited: 5 5, 2020.] https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/bndes-aprova-r-5-2-bilhoes-para-linha-de-transmissao-de-uhe-belo-monte-pa-ao-rj.

—. 2020. E-SIC. [Online] 2020. Data provided by BNDES through the Citizen Information Service Electronic System.. https://esic.cgu.gov.br/sistema/site/acesso_info.aspx.

Boadle, Anthony. 2017. State Grid buys $3.4 bln in CPFL from minority shareholders. *Reuters.* [Online] 11 30, 2017. [Cited: 5 5, 2020.] https://www.reuters.com/article/cpfl-energia-delisting/state-grid-buys-3-4-bln-in-cpfl-from-minority-shareholders-idUSL1N1O02LI.

Borges, Andre. 2017. Adversidades na Amazonia surpreendem grupo chines. [Online] 3 19, 2017. [Cited: 5 5, 2020.] https://economia.estadao.com.br/noticias/geral,adversidades-na-amazoniasurpreendem-grupo-chines,70001705188.

Boyle, Anthony. 2019. Brazil narrows field to China, Russia, France for Angra 3 nuclear partner. *Reuters.* [Online] 10 23, 2019. [Cited: 5 5, 202.] https://www.reuters.com/article/us-brazil-nuclear/brazil-narrows-field-to-china-russia-france-for-angra-3-nuclear-partner-idUSKBN1X22EA.

BP. 2019. Statistical Review of World Energy. *British Petroleum.* [Online] 6 30, 2019. [Cited: 5 5, 2020.] https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

—. 2020. Statistical Review of World Energy 2020. *British Petroleum.* [Online] 6 2020. [Cited: 9 9, 2020.] https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf.

Bugge, Axel. 2011. China Three Gorges buys EDP stake for 2.7 billion euros. *Reuters.* [Online] 12 22, 2011. [Cited: 5 5, 2020.] https://www.reuters.com/article/us-edp-threegorges-idUSTRE7BM04V20111223.

Cabré, Miquel, Gallagher, Kevin and Li, Zhongshu. 2018. Renewable Energy: The Trillion Dollar Opportunity for Chinese Overseas Investment. *China & World Economy.* 2018, Vol. 26, 6, pp. 27-49.

CAMEX. 2019. Foreign Investment Newsletter – Selected countries. *CAMEX.* [Online] 11 6, 2019. [Cited: 5 5, 2020.] https://www.gov.br/economia/pt-br/centrais-de-conteudo/publicacoes/boletins/boletim-de-investimentos-estrangeiros.

Caramuru, Marcus, Lins, Clarissa and Ferreira, Guilherme. 2019. Brasil-China: o estado da relação, Belt and Road e lições para o futuro. *CEBRI.* [Online] 10 31, 2019. [Cited: 5 5, 2020.] https://www.cebri.org/portal/publicacoes/cebri-artigos/brasil---china,-o-estado-da-relacao,-belt-and-road-e-licoes-para-o-futuro.

Castano, Ivan. 2018. CGN moves to buy Brazil's Atlantic. [Online] 11 8, 2018. [Cited: 5 5, 2020.] https://www.latinfinance.com/daily-briefs/2018/11/8/cgn-moves-to-buy-brazils-atlantic.

Castro, Nivalde, et al. 2017. *As Tarifas de Energia Elétrica no Brasil e em Outros Países: O Porquê das Diferenças.* Rio de Janeiro : Fabrica de Livros, 2017.

Cavalcante, Alina. 2018. *Pathway development in solar energy: a comparative study between Brazil and China.* Campinas : Unicamp, 2018. DIssertation.

CCTEC. 2020. Company Profile. *CCTEC.* [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://www.chinaccetc.com/en/about.aspx?cateid=97.

CEBC. 2019. Investimentos Chineses no Brasil. *China-Brazil Business Council.* [Online] 9 23, 2019. [Cited: 5 5, 2020.] https://cebc.org.br/investimentos-chineses-no-brasil/.

Climatescope. 2020. Brazil - Price environment. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://global-climatescope.org/results/BR#clean-energy-investment.

—. 2020. Emerging markets cross-border clean energy investment. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://global-climatescope.org/clean-energy-investments.

Cobrazil. 2019. UTE Pampa Sul é Cobrazil em acao para geracao de energia e desenvolvimento social. *Cobrazil.* [Online] 9 19, 2019. [Cited: 5 5, 2020.] http://www.cobrazil.com.br/ute-pampa-sul-e-cobrazil-em-acao-para-geracao-de-energia-e-desenvolvimento-social/.

Collet, Luciana and Magnabosco, André. 2014. Linhão de Belo Monte terá taxa retorno próxima a 10 percent. [Online] 2 7, 2014. [Cited: 5 5, 2020.] https://exame.com/economia/linhao-de-belo-monte-tera-taxa-retorno-proxima-a-10/.

Costa, Luciano. 2018. Chesf, da Eletrobras, contrata chinesa Goldwind em tentativa de retomar parque eólico. [Online] 4 19, 2018. [Cited: 5 5, 2020.] https://br.reuters.com/article/businessNews/idBRKBN1HQ2TA-OBRBS.

—. 2016. China Three Gorges Corp eyeing wind, solar projects in Brazil. [Online] 7 5, 2016. [Cited: 5 5, 2020.] https://www.reuters.com/article/us-ctgpc-brazil-interview-idUSKCN0ZL2SP.

—. 2018. Chinesa Goldwind fecha contrato de até R$450 mi com Energimp para eólicas, diz fonte. [Online] 6 26, 2018. [Cited: 5 5, 2020.] https://br.reuters.com/article/businessNews/idBRKBN1JM2A2-OBRBS.

—. 2016. CPFL conclui compra da distribuidora de energia AES Sul por R$2,8 bi. *Reuters.* [Online] 10 31, 2016. [Cited: 5 5, 2020.] https://br.reuters.com/article/topNews/idBRKBN12V2EX.

—. 2016. Italy's Enel buys Brazil's Celg-D for $647 million. *Reuters.* [Online] 11 30, 2016. [Cited: 5 1, 2020.] https://www.reuters.com/article/us-celgpar-m-a-enel-idUSKBN13P1XA.

—. 2017. World's No. 1 solar panel maker wants slice of Brazil market -executive. *Reuters.* [Online] 8 31, 2017. [Cited: 5 5, 2020.] https://www.reuters.com/article/us-brazil-power-trina-idUSKCN1BB2YQ.

—. 2017. World's No. 1 solar panel maker wants slice of Brazil market-executive. *Reuters.* [Online] 8 31, 2017. [Cited: 5 5, 2020.] https://www.reuters.com/article/us-brazil-power-trina-idUSKCN1BB2YQ.

Cote, Chris. 2014. State Grid's Bold Leap: Chinese Investment in Brazil's Transmission Sector. [book auth.] Margaret Myers and Viscidi Lisa. *Navigating Risk in Brazil's Energy Sector: the chinese approach.* Washington : Inter-American Dialogue, 2014, pp. 18-22.

CPFL. 2016. CPFL Energia anuncia acordo para a compra da AES Sul. *CPFL Energia.* [Online] 6 16, 2016. [Cited: 5 1, 2020.] https://www.cpfl.com.br/releases/Paginas/cpfl-energia-anuncia-acordo-para-a-compra-da-aes-sul.aspx.

—. 2019. CPFL Soluções investe R$ 21,7 milhões em fazenda solar para Algar Telecom em parceria com a Alsol. *CPFL.* [Online] 2 27, 2019. [Cited: 5 5, 2020.] https://www.cpfl.com.br/releases/Paginas/cpfl-solucoes-investe-21-milhoes-em-fazenda-solar-para-algar-telecom-em-parceria-com-a-alsol.aspx.

—. 2020. State Grid. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.cpfl.com.br/institucional/stategrid/Paginas/default.aspx.

—. 2017. State Grid adquire o controle acionário da CPFL Energia. *CPFL.* [Online] 1 23, 2017. [Cited: 5 5, 2020.] https://www.cpfl.com.br/releases/Paginas/state-grid-adquire-o-controle-acionario-da-cpfl-energia.aspx.

Cresesb. 2001. Atlas do Potencial Eolico Brasileiro. [Online] 2001. [Cited: 5 5, 2020.] http://www.cresesb.cepel.br/publicacoes/download/atlas_eolico/Atlas%20do%20Potencial%20Eolico%20Brasileiro.pdf.

Cui, Shoujun and Zheng, Zhang. 2019. China and Brazil Development Finance Cooperation: A case study of the Belo Monte Transmission Line Project. [book auth.] Enrique Peters. *China's Financing in Latin America and the Caribbean.* Mexico City : UNAM, 2019, pp. 235-258.

Cuperstein, Ilan. 2014. Weighing Local Risks and Opportunities: Sino-Brazilian Cooperation in Renewable Energy. [book auth.] Margaret Myers and Viscidi Lisa. *Navigating Risk in Brazil's Energy Sector.* Washington : Inter-American Dialogue, 2014, pp. 13-17.

—. 2014. Weighing Local Risks and Opportunities: Sino-Brazilian Cooperation in Renewable Energy. [book auth.] Margaret Myers and Lisa Viscidi. *Navigating Risk in Brazil's Energy Sector: the chinese approach.* Washington : Inter-American Dialogue, 2014, pp. 13-17.

Da Silva, Lucas. 2019. A pressão chinesa sobre o setor elétrico brasileiro. *Revista franco-brasilera de geografia.* 9 8, 2019, pp. 1-4.

DeaLogic. 2019. DeaLogic. [Online] 12 31, 2019. [Cited: 12 31, 2019.] https://www.dealogic.com/.

DiariodoNordeste. 2012. Parque solar com recursos chineses. [Online] 10 2, 2012. [Cited: 5 5, 2020.] https://diariodonordeste.verdesmares.com.br/negocios/parque-solar-com-recursos-chineses-1.639194.

Dieese. 2015. Comportamento das tarifas de energia elétrica no Brasil. [Online] 8 31, 2015. [Cited: 5 5, 2020.] https://www.dieese.org.br/notatecnica/2015/notaTec147eletricidade.html.

—. 2017. *Privatização, desnacionalização e terceirização no setor elétrico brasileiro.* Sao Paulo : Dieese, 2017. Nota tecnica.

EDP. 2019. EDP adquire empreendimento de transmissão no mercado secundário. [Online] 5 28, 2019. [Cited: 5 5, 2020.] https://www.edp.com.br/noticias/edp-adquire-empreendimento-de-transmissao-no-mercado-secundario.

—. 2018. EDP conclui aquisição de participação na CELESC. *EDP.* [Online] 3 22, 2018. [Cited: 5 5, 2020.] https://www.edp.com.br/noticias/edp-conclui-aquisicao-de-participacao-na-celesc.

—. 2018. EDP conclui aquisição de participação na CELESC. *EDP.* [Online] 3 22, 2018. [Cited: 5 5, 2020.] https://www.edp.com.br/noticias/edp-conclui-aquisicao-de-participacao-na-celesc.

EIA. 2020. International electricity net consumption. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.eia.gov/international/data/world/electricity/electricity-consumption?pd=2&p=0000002&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&vb=33&t=C&g=00000000000000000000000000000000000000000001&l=249-ruvvvvvfvtvnvv1vrvvvvfvvvvvvfvvvou20evvvvvvvvvvvv.

Eletrobras. 2020. E-SIC. [Online] 2020. Data provided by the company through the Citizen Information Service Electronic System (E-SIC). https://esic.cgu.gov.br/sistema/site/acesso_info.aspx.

Eletrosul. 2017. Eletrosul, Shanghai Electric e Clai Fund assinam acordo para investimentos no Rio Grande do Sul. *Eletrosul.* [Online] 11 17, 2017. [Cited: 5 5, 2020.] http://www.eletrosul.gov.br/sala-de-imprensa/noticias/eletrosul-shanghai-electric-e-clai-fund-assinam-acordo-para-investimentos-no-rio-grande-do-sul.

Enel. 2019. Enel sells 540 MW of renewable capacity in Brazil for 700 million euros. *Enel.* [Online] 1 16, 2019. [Cited: 5 5, 2020.] https://www.enelgreenpower.com/media/press/d/2019/01/enel-sells-540-mw-of-renewable-capacity-in-brazil-for-700-million-euros.

—. 2019. Enel sells 540 MW of renewable capacity in Brazil for 700 million euros. *Enel Green Power.* [Online] 1 16, 2019. [Cited: 5 5, 2020.] https://www.enelgreenpower.com/media/press/2019/01/enel-sells-540-mw-of-renewable-capacity-in-brazil-for-700-million-euros.

EnergiasRenovables. 2011. La china Sinovel entra al mercado eólico. [Online] 9 24, 2011. [Cited: 5 5, 2020.] https://www.energias-renovables.com/eolica/la-china-sinovel-entra-al-mercado-eolico.

ENR. 2019. ENR's 2019 Top 250 International Contractors. *Engineering News-Record.* [Online] 8 31, 2019. [Cited: 5 5, 2020.] https://www.enr.com/toplists/2019-Top-250-International-Contractors-1.

EPE. 2019. Anuário Estatístico de Energia Elétrica 2019. *EPE.* [Online] 12 1, 2019. [Cited: 5 5, 2020.] http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-160/topico-168/Anu%C3%A1rio_2019_WEB.pdf.

—. 2020. Anuário Estatístico de Energia Elétrica 2020. *EPE.* [Online] 2020. [Cited: 9 9, 2020.] https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/anuario-estatistico-de-energia-eletrica.

—. 2020. Balanço Energético Nacional 2020. *EPE.* [Online] 1 21, 2020. [Cited: 5 5, 2020.] http://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/balanco-energetico-nacional-2020.

—. 2016. Demanda de energia 2050. [Online] 1 1, 2016. [Cited: 5 5, 2020.] https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-227/topico-458/DEA%2013-15%20Demanda%20de%20Energia%202050.pdf.

—. 2020. Fontes. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.epe.gov.br/pt/areas-de-atuacao/energia-eletrica/expansao-da-geracao/fontes.

—. 2020. Plano Decenal de Expansão de Energia 2029. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2029.

—. 2012. Plano Decenal de Expansão de Energia – PDE 2021. [Online] 12 31, 2012. [Cited: 5 5, 2020.] http://www.mme.gov.br/documents/36208/461966/07+-+Plano+Decenal+de+Expans%C3%A3o+de+Energia+-+PDE+2021/c6f4d6d5-b358-de37-01cb-0a1d786a5881?version=1.1.

—. 2006. Plano Nacional de Energia - 2030. [Online] 4 18, 2006. [Cited: 5 5, 2020.] https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/Plano-Nacional-de-Energia-PNE-2030.

—. 2018. Premissas para a inserção de energia eólica na expansão do SIN. [Online] 2018. [Cited: 5 5, 2020.] http://www.epe.gov.br/sites-pt/acesso-restrito/Documents/2018_Revista%20Cenarios%20E%C3%B3lica_%20Premissas%20PDE.pdf.

fDiIntelligence. 2019. fDi Intelligence. [Online] 12 31, 2019. [Cited: 12 12, 2019.] https://www.fdiintelligence.com/.

Fifa. 2014. Solar on the World Stage: Yingli Solar and the 2014 FIFA World Cup. *Fifa.* [Online] 10 15, 2014. [Cited: 5 5, 2020.] https://www.fifa.com/worldcup/videos/solar-on-the-world-stage-yingli-solar-and-the-2014-fifa-world-cup-2457507.

Freire, Wagner. 2016. Potencial eólico onshore brasileiro pode ser de 880 GW, indica estudo. [Online] 10 26, 2016. [Cited: 5 5, 2020.] https://www.canalenergia.com.br/noticias/31738562/potencial-eolico-onshore-brasileiro-pode-ser-de-880-gw-indica-estudo.

Fusoes&Aquisicoes. 2017. Chinesa Shenzhen Center Power adquire a brasileira Unicoba Baterias. *Fusoes & Aquisicoes.* [Online] 6 1, 2017. [Cited: 5 5, 2020.] https://fusoesaquisicoes.blogspot.com/2017/06/chinesa-shenzhen-center-power-adquire.html.

G1. 2017. Linha de transmissão que liga Hidrelétrica de Belo Monte ao Sudeste do país é inaugurada em MG. [Online] 12 21, 2017. [Cited: 5 5, 2020.] https://g1.globo.com/mg/sul-de-minas/noticia/linha-de-transmissao-que-liga-hidreletrica-de-belo-monte-ao-sudeste-do-pais-e-inaugurada-em-mg.ghtml.

Gallagher, Kevin. 2019. China's Global Energy Finance. *Global Development Policy Center.* [Online] 12 31, 2019. [Cited: 5 5, 2020.] https://www.bu.edu/cgef/#/all/Country.

Gallagher, Kevin, et al. 2019. *China's Global Power Database.* Boston : Boston University, 12 31, 2019. Global Development Policy Center, Boston University.

Gallagher, Kevin, et al. 2018. Energizing development finance? The benefits and risks of China's development finance in the global energy sector. *Energy Policy.* 8 2, 2018, pp. 313-321.

GazetadoPovo. 2016. Governo chinês vai financiar ônibus elétricos da BYD no Brasil. *Gazeta do Povo.* [Online] 12 8, 2016. [Cited: 5 5, 2020.] https://www.gazetadopovo.com.br/economia/energia-e-sustentabilidade/governo-chines-vai-financiar-onibus-eletricos-da-byd-no-brasil-av0ywihuunrh-f6gmt4r2spa5s/.

GEIDCO. 2020. Global Energy Interconnection Development and Cooperation Organization. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.geidco.org/.

—. 2018. Global Energy Interconnection Standard System Research. [Online] 2018. [Cited: 5 5, 2020.] https://m.geidco.org/pcarticle/1410.

Goldwind. 2018. China's Goldwind enters Brazil with $270m Energimp deal. [Online] 6 29, 2018. [Cited: 5 5, 2020.] http://www.goldwindglobal.com/news/focus-article.html?id=2047.

Gopal, Sucharita, et al. 2018. Fueling Global Energy Finance: The Emergence of China in Global Energy Investment. *Energies.* 10 18, 2018, Vol. 11, 2804, pp. 1-25.

Gorini, Ricardo. 2018. Custos de Geração de Energia Renovável. *IRENA.* [Online] 8 31, 2018. [Cited: 5 5, 2020.] https://drudu6g9smo13.cloudfront.net/wp-content/uploads/2018/08/PPT_GORINI_IRENA_Brazil-Wind-Power_08.Aug_.18_vf_port6.pdf.

Greenhill. 2019. TPP Camaçari Muricy II & TPP Pecem II. [Online] 1 18, 2019. [Cited: 5 5, 2020.] https://www.greenhill.com/en/content/tpp-cama%C3%A7ari-muricy-ii-tpp-pecem-ii.

Griffiths, James. 2019. China can shut off the Philippines' power grid at any time, leaked report warns. *CNN.* [Online] 11 26, 2019. [Cited: 5 5, 2020.] https://www.cnn.com/2019/11/25/asia/philippines-china-power-grid-intl-hnk/index.html.

GWEC. 2020. Global Wind Report 2019. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://gwec.net/global-wind-report-2019/#:~:text=The%20Global%20Wind%20Report%202019%20highlights%20a%20positive%20market%20outlook,installations%20each%20year%20until%202024.

Hiratuka, Celio. 2018. Chinese Infrastructure Projects in Brazil: two case studies. [book auth.] Enrique Peters, Ariel Armony and Shoujun Cui. *Building Development for a New Era: China's Infrastructure Projects in Latin America and the Caribbean.* Mexico City : University of Pittsburgh, 2018, pp. 122-143.

—. 2019. Chinese OFDI in Brazil. [book auth.] Enrique Peters. *China`s Foreign Direct Investment in Latin America and the Caribbean: conditions and challenges.* Mexico City : Unam, 2019, pp. 167-188.

Hochstetler, Kathryn and Kostka, Genia. 2015. Wind and Solar Power in Brazil and China: Interests, State–Business Relations, and Policy Outcomes. *Global Environmental Politics.* 5 1, 2015, pp. 74-94.

Husar, Joerg and Best, Dennis. 2013. Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China. *International Energy Agency.* [Online] 12 11, 2013. [Cited: 5 5, 2020.] https://www.oecd.org/brazil/energy-investments-and-technology-transfer-across-emerging-economies-the-case-of-brazil-and-china-9789264247482-en.htm.

IBGE. 2019. Estimativas da População. *IBGE.* [Online] 7 1, 2019. [Cited: 5 5, 2020.] https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=resultados.

—. 2020. Produto Interno Bruto. *IBGE.* [Online] 5 1, 2020. [Cited: 5 1, 2020.] https://www.ibge.gov.br/explica/pib.php.

Investing.com. 2020. USD/BRL - US Dollar Brazil Real. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.investing.com/currencies/usd-brl-historical-data.

IRENA. 2020. Country Rankings. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings.

—. 2020. Global trends in renewable energy investment. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.irena.org/Statistics/View-Data-by-Topic/Finance-and-Investment/Investment-Trends.

JASolar. 2020. Global Project References. *JA Solar.* [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://www.jasolar.com/index.php?m=content&c=index&a=lists&catid=65&leixin=&zhouji=4&page=.

Jinjiang. 2018. Incorporation of subsidiary in Brazil. *Jinjiang Environment.* [Online] 8 10, 2018. [Cited: 5 5, 202.] http://www.jinjiang-env.com/uploadfiles/201808/15341314414544.pdf.

JornaldoComercio. 2018. Sem Bndes, Candiota 3 busca crédito na China. *Jornal do Comercio.* [Online] 2 14, 2018. [Cited: 5 5, 2020.] https://www.jornaldocomercio.com/_conteudo/2018/02/economia/611238-sem-bndes-candiota-3-busca-credito-na-china.html.

JornalMinuano. 2019. Ouro Negro e Sepco 1 assinam contrato para construção de usina em Pedras Altas. *Jornal Minuano.* [Online] 10 1, 2019. [Cited: 5 5, 2020.] http://www.jornalminuano.com.br/noticia/2019/10/01/ouro-negro-e-sepco-1-assinam-contrato-para-construcao-de-usina-em-pedras-altas.

JornalTribunadoPampa. 2019. UTE Ouro Negro assina contrato bilionário com a chinesa Sepco1 e se prepara para vender energia no mercado livre. *Jornal Tribuna do Pampa.* [Online] 9 28, 2019. [Cited: 5 5, 2020.] https://noticiasutepampasul.blogspot.com/2019/09/.

Kong, Bo and Gallagher, Kevin. 2020. Chinese development finance for solar and wind power abroad. [Online] 2 5, 2020. [Cited: 5 5, 2020.] https://www.bu.edu/gdp/2020/02/05/chinese-development-finance-for-solar-and-wind-power-abroad/.

—. 2017. Globalizing Chinese Energy Finance: The Role of Policy Banks. *Journal of Contemporary China.* 6 25, 2017, pp. 1-18.

Kong, Bo. 2019. *Modernization Through Globalization: Why China Finances Foreign Energy Projects Worldwide.* Singapure : Palgrave MacMillan, 2019.

Leite, Alexandre and Vanderlei, Gary. 2017. China-Brazil technical cooperation: An analysis of the Incorporation Movements of the State Grid Corporation in the Brazilian Energy Sector. *Revista Internacional de Cooperación y Desarollo.* 2017, Vol. 4, 2, pp. 85-105.

Li, Zhangshu, Gallagher, Kevin and Mauzerall, Denise. 2018. Estimating Chinese Foreign Investment in the Electric Power Sector. *Global Development Policy Center.* [Online] 10 31, 2018. [Cited: 5 5, 2020.] https://www.bu.edu/gdp/2018/10/04/estimating-chinese-foreign-investment-in-the-electric-power-sector/.

LNTrans. 2017. Relatorio de Administracao 2016. [Online] 4 20, 2017. [Cited: 5 5, 2020.] http://www.lntrans.com.br/wp-content/uploads/2017/07/2016.pdf.

Lopez, Blanca. 2017. Canadian Solar logra US$20 millones del CPDFund para proyectos fotovoltaicos en Brasil. [Online] 3 7, 2017. [Cited: 5 5, 2020.] https://www.pv-magazine-latam.com/2017/03/07/canadian-solar-logra-us-20-del-cpdfund-para-proyectos-fotovoltaicos-en-brasil/.

—. 2016. Canadian Solar manufacturing facility inaugurated in Sao Paulo. *PV Magazine*. [Online] 12 9, 2016. [Cited: 5 5, 2020.] https://www.pv-magazine.com/2016/12/09/canadian-solar-manufacturing-facility-inaugurated-in-sao-paulo_100027170/.

Ma, Xinyue, Gallagher, Kevin and Guo, Yanan. 2019. China's Global Energy Finance 2019. *Global Development Policy Center.* [Online] 2 1, 2019. [Cited: 5 5, 2020.] https://www.bu.edu/gdp/files/2020/02/Policy-Brief-2019-Ma-Gallagher-Guo.pdf.

MacauHub. 2018. Empresas da China e Brasil vão actuar no sector de energia do Rio Grande do Sul. [Online] 8 28, 2018. [Cited: 5 5, 2020.] https://macauhub.com.mo/pt/2018/08/28/pt-empresas-da-china-e-brasil-vao-actuar-no-sector-de-energia-do-rio-grande-do-sul/.

MarketScreener. 2013. EDP - Energias do Brasil SA : Material Fact Partnership CTG. *Market Screener.* [Online] 12 6, 2013. [Cited: 5 5, 2020.] https://www.marketscreener.com/EDP-ENERGIAS-DO-BRASIL-6497940/news/EDP-Energias-do-Brasil-SA-Material-Fact-Partnership-CTG-17597143/.

Molina, Pilar. 2019. Canadian solar obtiene otros 120 millones de dólares de financiación para proyectos de energía solar en Brasil. [Online] 8 28, 2019. [Cited: 5 5, 2020.] https://www.pv-magazine-latam.com/2019/08/28/canadian-solar-obtiene-otros-120-millones-de-dolares-de-financiacion-para-proyectos-de-energia-solar-en-brasil/.

Nari. 2020. Quem somos. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://www.narigroup.com/br/empresa/.

—. 2020. SobreNos. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://www.narigroup.com/br/empresa/.

NariBrasil. 2015. NARI GROUP foi confirmada vencedora para fornecer tecnologia de ponta em UHVDC ± 800kV para o 2º Bipolo da Usina Hidrelétrica de Belo Monte. [Online] 11 30, 2015. [Cited: 5 5, 2020.] http://www.narigroup.com/br/noticias/ver.php?id=9.

NDB. 2017. Financing of renewable energy projects and associated transmission. [Online] 4 26, 2017. [Cited: 5 5, 2020.] https://www.ndb.int/bndes-brazil/.

NE10. 2016. Empresa S4 Solar do Brasil lança fábrica de painéis solares no Estado. [Online] 9 14, 2016. [Cited: 5 5, 2020.] https://jc.ne10.uol.com.br/canal/economia/pernambuco/noticia/2016/09/14/empresa-s4-solar-do-brasil-lanca-fabrica-de-paineis-solares-no-estado-252866.php.

NEA. 2016. 13th Renewable Energy Development Five Year Plan (2016-2020). *National Energy Administration.* [Online] 12 10, 2016. [Cited: 5 5, 2020.] http://www.nea.gov.cn/135916140_14821175123931n.pdf.

Nepomuceno, Marcelo. 2013. Empresa de painéis solares chinesa instalará unidade em São Leopoldo. [Online] 12 4, 2013. [Cited: 5 5, 2020.] https://estado.rs.gov.br/empresa-de-paineis-solares-chinesa-instalara-unidade-em-sao-leopoldo.

Ng, Eric. 2016. Australia formally rejects bids by State Grid and Cheung Kong Infrastructure for Ausgrid. *South China Morning Post.* [Online] 8 19, 2016. [Cited: 5 5, 2020.] https://www.scmp.com/business/companies/article/2006217/australia-formally-rejects-bids-state-grid-and-cheung-kong.

Odebrecht. 2019. Odebrecht Latinvest conclui a venda da Central Hidrelétrica Chaglla, no Peru. *Odebrecht.* [Online] 4 26, 2019. [Cited: 5 5, 2020.] https://www.odebrecht.com/pt-br/comunicacao/noticias/odebrecht-latinvest-conclui-a-venda-da-central-hidreletrica-chaglla-no-peru.

OGlobo. 2010. Estatal da China compra controle de sete empresas de energia no Brasil, diz 'Valor'. [Online] 5 18, 2010. [Cited: 5 5, 2020.] https://oglobo.globo.com/economia/estatal-da-china-compra-controle-de-sete-empresas-de-energia-no-brasil-diz-valor-3007244#ixzz4VV9zN0ZA.

Oliveira, Gesner, et al. 2018. Análise do ambiente concorrencial do setor elétrico no Brasil. *FGV.* [Online] 2018. [Cited: 5 5, 2020.] https://gei-sa.fgv.br/sites/gei-sa.fgv.br/files/u49/go_estudo_concorrencial_energia_fgv.pdf.

ONS. 2020. Capacidade instalada de geração. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/capacidade_instalada.aspx.

—. 2020. Extensão das Linhas de Transmissão. [Online] 5 5, 2020. [Cited: 5 5, 2020.] http://www.ons.org.br/Paginas/resultados-da-operacao/historico-da-operacao/extensao_linhastransmissao.aspx.

PacificHydroBrasil. 2017. Sobre a Pacific Hydro Brasil. *PacificHydroBrasil.* [Online] 2017. [Cited: 5 5, 2020.] http://pacifichydro.com.br/portuguese/sobre-nos/sobre-a-pacific-hydro-brasil/?language=pt.

Pamplona, Nicola. 2017. Empresa chinesa inicia obra de linha de transmissão de R$ 9,5 bilhões. [Online] 9 28, 2017. [Cited: 5 5, 2020.] https://www1.folha.uol.com.br/mercado/2017/09/1922589-empresa-chinesa-inicia-obra-de-linha-de-transmissao-de-r-95-bilhoes.shtml.

Pereira, Enio, et al. 2017. *Atlas brasileiro de energia solar.* Sao Jose dos Campos : INPE, 2017.

Pinto, Paulo, Mali, Tiago and Nobrega, Ighor. 2020. China tem 99 percent do mercado de US$1 bilhão de painéis solares no Brasil. [Online] 1 12, 2020. [Cited: 5 5, 2020.] https://www.poder360.com.br/economia/china-tem-99-do-mercado-de-us-1-bilhao-de-paineis-solares-no-brasil/.

Proctor, Darrell. 2020. Vestas, Siemens Gamesa, GE Top Wind Turbine Growth. [Online] 218, 2020. [Cited: 5 5, 2020.] https://www.powermag.com/vestas-siemens-gamesa-ge-top-wind-turbine-growth/.

Proenca, Adriano and Kupfer, David. 2018. Experiencias empresariais. [book auth.] Anna Jaguaribe. *Direction of Chinese Global Investments Implications for Brazil.* Brasilia : FUNAG, 2018, pp. 267-289.

Quilter, James. 2012. Desenvix retreats from Sinovel court order. [Online] 8 10, 2012. [Cited: 5 5, 2020.] https://www.windpowermonthly.com/article/1144935/desenvix-retreats-sinovel-court-order.

RedALC. 2020. OFDI china a nivel de empresa (2000-2019). *RedALC.* [Online] 3 18, 2020. [Cited: 5 5, 2020.] https://www.redalc-china.org/monitor/informacion-por-pais/busqueda-por-pais/29-brasil.

Reed, Sarita and Fontana, Vinicius. 2018. Dono das maiores reservas de carvão do Brasil, RS acena para China em busca de investidores. *Dialogo Chino.* [Online] 12 12, 2018. [Cited: 5 5, 2020.] https://dialogochino.net/15659-dono-das-maiores-reservas-de-carvao-do-brasil-rs-acena-para-china-em-busca-de-investidores/?lang=pt-br.

Reuters. 2017. Chinesa Goldwind avalia compra de projetos eólicos para entrar no Brasil. [Online] 10 16, 2017. [Cited: 5 5, 2020.] https://epocanegocios.globo.com/Empresa/noticia/2017/10/chinesa-goldwind-avalia-compra-de-projetos-eolicos-para-entrar-no-brasil.html.

—. 2017. Chinesa Goldwind avalia compra de projetos eólicos para entrar no Brasil. *Epoca.* [Online] 10 16, 2017. [Cited: 5 5, 2020.] http://epocanegocios.globo.com/Empresa/noticia/2017/10/chinesa-goldwind-avalia-compra-de-projetos-eolicos-para-entrar-no-brasil.html.

Ribeiro, Rafael. 2019. Gigante chinesa estuda instalar fábrica em MS. [Online] 9 1, 2019. [Cited: 5 5, 2020.] https://www.correiodoestado.com.br/cidades/gigante-chinesa-estuda-instalar-fabrica-de-montagem-de-paineis-solares/359831/.

RioParanaEnergia. 2017. Demonstrações financeiras em 31 de dezembro de 2017. *CTG.* [Online] 12 31, 2017. [Cited: 5 5, 2020.] http://ctgbr.com.br/wp-content/uploads/2018/09/Demonstracoes-Financeiras-31.12.2017.pdf.

Rockmann, Roberto. 2019. Estatais estrangeiras gastam R$ 120 bi no setor de infraestrutura do Brasil, e movimento vai crescer Este trecho é parte de conteúdo que pode ser compartilhado utilizando o link https://valor.globo.com/eu-e/noticia/2019/06/14/estatais-estrangeiras-gast. *Valor Economico.* [Online] 6 14, 2019. [Cited: 5 5, 2020.] https://valor.globo.com/eu-e/noticia/2019/06/14/estatais-estrangeiras-gastam-r-120-bi-no-setor-de-infraestrutura-do-brasil-e-movimento-vai-crescer.ghtml.

Santana, Andre. 2018. Corona Energy pode instalar fábrica de placas solares em MT; empresa já tem filial em SP. [Online] 1 25, 2018. [Cited: 5 5, 2020.] https://www.agroolhar.com.br/noticias/exibir.asp?id=25964&noticia=corona-energy-pode-instalar-fabrica-de-placas-solares-em-mt-empresa-ja-tem-filial-em-sp.

SASAC. 2020. Yangqi Minglu [List of central SOEs]. *SASAC.* [Online] 3 31, 2020. [Cited: 5 5, 202.] http://www.sasac.gov.cn/n2588035/n2641579/n2641645/index.html.

Schutte, Giorgio and Debone, Victor. 2017. A Expansão dos Investimentos Externos Diretos Chineses: o caso do setor energético brasileiro. *Conjuntura Astral.* 10 1, 2017, pp. 90-113.

Scrivano, Roberto. 2018. Sem incentivos, fabricantes de painéis solares agonizam no Brasil. [Online] 8 13, 2018. [Cited: 5 5, 2020.] https://oglobo.globo.com/economia/sem-incentivos-fabricantes-de-paineis-solares-agonizam-no-brasil-22971029.

Sebrae. 2017. Cadeia de valor da energia solar fotovoltaica no Brasil. *Sebrae.* [Online] 2017. [Cited: 5 5, 2020.] https://m.sebrae.com.br/Sebrae/Portal%20Sebrae/Anexos/estudo%20energia%20fotovolt%C3%A1ica%20-%20baixa.pdf.

SECEX. 2006. *Relatório Sintético do Levantamento de Auditoria.* Brasilia : Camara dos Deputados, 2006.

Silveira, Laura. 2018. *Laços e traçados da China no Brasil- implantação de infraestrutura energética e a componente socioambiental.* UNB. Brasilia : UNB, 2018. Dissertation.

Sinovel. 2011. Desenvix taps Chinese bank for $55m to fund Brazil wind farm. [Online] 9 11, 2011. [Cited: 5 5, 2020.] http://www.sinovel.com/english/content/?144.html.

StateGrid. 2019. XRTE recebe LO para iniciar as operacoes. [Online] 12 1, 2019. [Cited: 5 5, 2020.] https://www.stategrid.com.br/xrte-recebe-lo-para-iniciar-as-operacoes/.

Tang, Charles. 2017. *Investimentos Chineses no Setor Energético Brasileiro: Oportunidades para o Brasil.* FGV. Sao Paulo : FGV, 2017.

Boston University
53 Bay State Road
Boston, MA 02215

gdp@bu.edu
@GDPC_BU
bu.edu/gdp

The Global China Initiative (GCI) is a research inititiative at Boston University's Global Development Policy Center. The GDP Center is a University wide center in partnership with the Frederick S. Pardee School for Global Studies. The Center's mission is to advance policy-oriented research for financial stability, human wellbeing, and environmental sustainability.

www.bu.edu/gdp

The views expressed in this Working Paper are strictly those of the author(s) and do not represent the position of Boston University, or the Global Development Policy Center.

Tang, Shihua. 2018. China's Jinlihua Electric Plans Brazilian Plant to Tap Power Grid Demand. *Yicai.* [Online] 6 11, 2018. [Cited: 5 5, 2020.] https://www.yicaiglobal.com/news/china-jinlihua-electric-plans-brazilian-plant-to-tap-power-grid-demand.

TribunadoNorte. 2019. Estatal chinesa de energia deve investir R$ 2 bilhoes no RN. *Tribuna do Norte.* [Online] 7 26, 2019. [Cited: 5 5, 2020.] http://www.tribunadonorte.com.br/noticia/estatal-chinesa-de-energia-deve-investir-r-2-bilha-es-no-rn/455093.

Unctad. 2020. World Investment Report 2020. [Online] 6 7, 2020. [Cited: 7 5, 2020.] https://unctad.org/en/Pages/Publications/WorldInvestmentReports.aspx.

Vanderlei, Gary. 2018. *State Grid: a inserção chinesa no setor elétrico brasileiro.* Joao Pessoa : Universidade Federal da Paraiba, 2018.

Weissheimer, Marco. 2017. De olho no carvão do RS, China quer reduzir uso do mineral em sua matriz energética. [Online] 126, 2017. [Cited: 5 5, 2020.] https://www.sul21.com.br/breaking-news/2017/01/de-olho-no-carvao-do-rs-china-quer-reduzir-uso-do-mineral-em-sua-matriz-energetica/.

WorldBank. 2020. Brazil GDP annual growth percent. [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2018&locations=BR&start=1961&view=chart.

—. 2020. GDP (current US$). [Online] 5 5, 2020. [Cited: 5 5, 2020.] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

Xiaoshan19lou. 2012. Zhongguo jianzao de nanmeizhou diyi shudian gaota kaishi zuli [The first transmission tower in South America built by China begins to be assembled]. *Xiaoshan19lou.* [Online] 7 25, 2012. [Cited: 5 5, 2020.] https://xiaoshan.19lou.com/forum-1653-thread-149701334740369839-1-1.html.

Xu, Yanran. 2019. Zhongguo yu baxi de kezaisheng nengyuan hezuo [China and Brazil Cooperation in Renewable Energy]. *Contemporary Finance & Economics.* 3 6, 2019, 4, pp. 110-118.

Zhu, Charlie and Chen, Michelle. 2012. China's State Grid to buy Brazil assets from Spain's ACS. *Reuters.* [Online] 5 29, 2012. [Cited: 5 5, 2020.] https://www.reuters.com/article/us-state-grid-brazil/chinas-state-grid-to-buy-brazil-assets-from-spains-acs-idUSBRE84S0C520120529.