Brazil and China: on the road to energy transition?

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Abstract: This work compares the policies of Brazil and China regarding the stimulation of solar and wind energy sources as a way of energy transition. Their results points to the fact that although China is a highly polluting country considering its energy matrix, at the same time it has strongly stimulated the renewables in question, making a prosperous and innovative national renewable energy industry. Meanwhile, Brazil have a relatively clear energy matrix, but is facing problems in the stimulation of the new renewables, with a trajectory marked, mainly, by discontinuities.

Key-words: Development. Climate Change. Energy Security. Low Carbon Energy. Brazil. China.

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Introduction

In the last decades humanity became aware of the serious damages caused by human activities to the Earth and so to the human living, something summarized by the global warming narrative, which brings the reduction of CO2 emissions as an imperative. Considering that the emissions of greenhouse gases (GHG) are strongly related to the way the states organize their energy market to keep their economic development and in many cases are the main causes of their GHG emissions, in this work we aim to compare the policies of Brazil and China regarding to the stimulation of green energy consume and innovation, specifically from solar and wind sources as parts of their contemporary strategies of energy security. In other words, we investigate politics made by the states which have as a goal to stimulate energy innovations and the use of sources considerably more renewable and cleaner than the previous ones.

Being mindful that leading states in terms of industrial activity are also the greatest GHG producers, we consider that the states have a considerable responsibility in achieve it, and that emerging countries have to be watched closely, because of their huge economic relevance, population size, recent urbanization process and the growing of

consumerism inside them. This way, from the assumption that energy is crucial if we want to talk about development and its quality today, and that the so-called emerging countries have real importance to achieve the global climate goals we investigate what is China have been doing to become greener in terms of energy, and what Brazil is doing to remain green in its energy production.

To elaborate this article, we proceeded a literature review and made use of many qualitative and quantitative sources of secondary data like International Energy Agency (IEA), The International Renewable Energy Agency (IRENA) and the governments of each country, often making use of simple descriptive statistic procedures. Through a comparative analysis of Brazil and China's renewable energy promotion policies we hope to identify which policy incentives and strategic actions have been used by these emerging countries as a way of ensuring energy security in a broad sense, considering supply and innovation as they are key to reductions in GHG emissions nowadays.

After this brief introduction, we discuss the main reasons that triggered a global search for renewable energy, then we show how each country consume energy, what are the incentive mechanisms for the production and consumption of renewable energies, and then we discuss the situation of production and consumption of wind and solar energy in both countries.

A new reality has begun

The twentieth century was characterized by and energy transition which made the oil the dominant source of energy, boosting and flexing economies around the world, with clear impact for the fueling in the transportation sector, for the industry and to a whole new way of life, considered modern in general. Despite its huge importance, this shift doesn’t change the fact that the fossil fuels are fundamental to the economic development since the industrial revolution in 18th century.

But this story did not happen without some mishaps. After the second world war (WWII), that the countries members of Organization of the Petroleum Exporting Countries (OPEC) started to use their dominance in the sector as a political weapon and generated the first big oil crisis that dominated the scene from the 1970`s to the 1980`s,

as a consequence of a suspension of oil supply to United States and Europe by the OPEC members, which have among their founding members countries such as Saudi Arabia, Kuwait, Iraq, Iran and Venezuela. At that time, OPEC countries demanded higher oil prices on the production sector, starting a war against the West cartel of petroleum companies.

This crisis has gone until 1986, the price of the oil barrel has been up to 400%, resulting in resections and, consequently, a huge destabilization of the world economy. This context, summed with a plenty of projections of a peak oil, provoked a first relevant wave of investments in new energy technologies, since the general adoption of petroleum as the main fuel. At first called "alternative energies, they become intensely researched, through the development of studies on biofuels and energies from sources like sun and wind, aside from researches on energy efficiency.

At the beginning of the twentieth first century, beyond the geopolitical worries, a series of critics about the impacts of the current economic development model started to be heard at least since the 1960`s definitely enters the global agenda, considering the terrifying environmental damages, caused by a human behavior which can be highly pollutant and devastating when despise the nature and its resources . Adds to this the fact that it was proven a climate change provoked by a global warming, product of emissions of harmful gases from human actions, with great potential to harm the human life at the Earth itself.

Today, it is understood that avoid the undesirable consequences of a business as usual (BAU) scenario, one of the key conditions is to reduce the emissions of gases associated to greenhouse effect in a worldwide scale. To reach this goal, energy have a fundamental role since, according to the International Energy Agency (IEA, 2016), the production and use of energy are responsible for two-thirds of the global emissions of greenhouse gases (GHG).

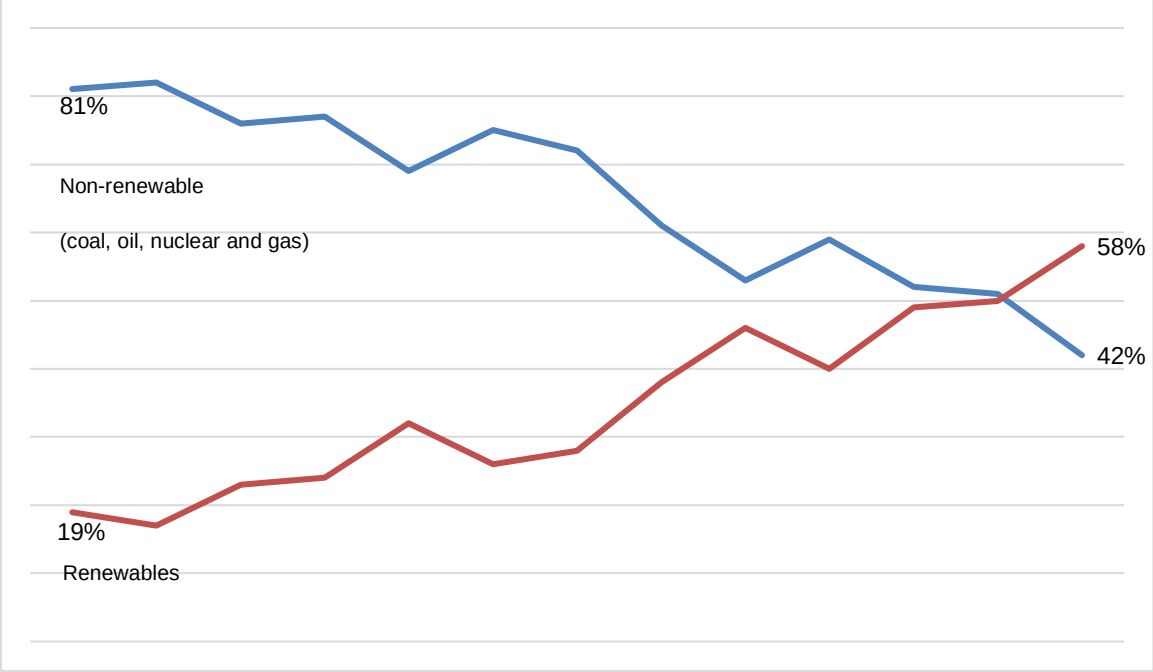
Therefore, a global energy transition from fossil sources to renewable ones, followed by better energy efficiency, or; a revolution of clean energy is not only desirable but also viable to achieve the climate goals in the long term, as those stablished by the UN Climate Convention for the energy.

Things are already changing, and nowadays, the demand for energy only grows due to international pressions for decarbonization, and factors such as economic growth, population growth, industrialization, urbanization and a qualified access to energy in the developing countries, governments seek to sustainable solutions as a way to obtain their goals on both energy security and sustainability (IRENA, 2017).

Today, the developing countries are fundamental in the global energy market (GÓMEZ et al., 2012), consolidating not only as importers but as exporters, and not only of commodities but also with knowledge and technological innovations related to the traditional and renewable energy sources. Chart 1, bellow, demonstrates the increasing of global investments on renewable energies since the beginning o the century.

One can understand that between 2001 and 2013, there was a significant fall on the investments intended to non-renewable energy such as coal, oil, nuclear and natural gas. At the same time we can observe a meaningful rise of the investments on renewable energies, which make the lines to cross the traditional tendency between 2012 and 2013, when the investments on renewables are 58%, overcoming those to non-renewables which so represents 42% (GONÇALVES, 2015).

Chart 1 – Renewable energies as added part of global capacity



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total net capacity addedper year	**104**	**134**	**150**	**153**	**134**	**180**	**200**	**174**	**185**	**232**	**234**	**233**	**207**
Renewables	20	22	34	36	41	47	56	67	85	94	115	116	120
Non-renewables	84	111	116	116	93	133	145	107	100	138	118	117	87

Own elaboration based in data from IRENA, 2014.

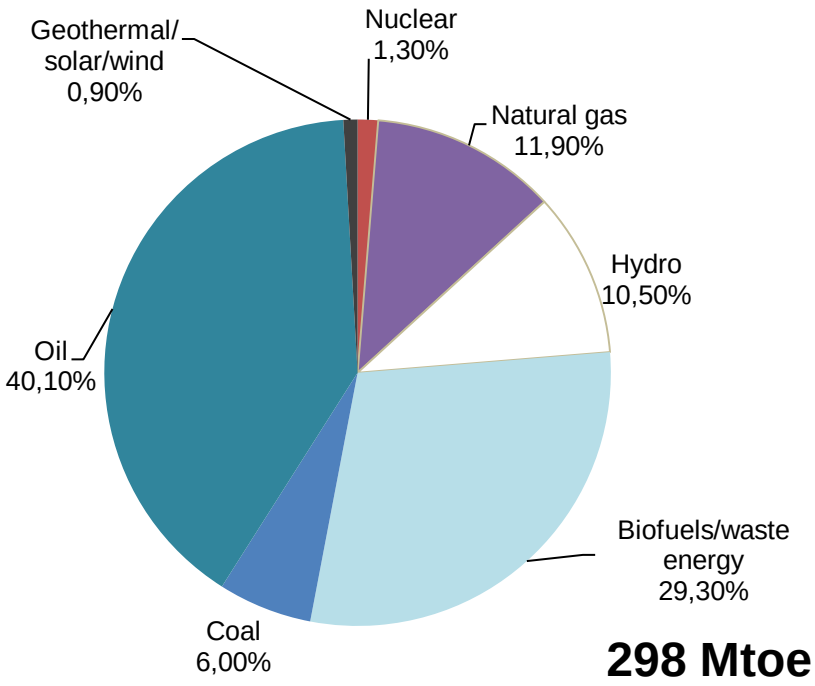
This tendency leads us to question how states have participated in this process and whether or not they encourage policies that favor the energy transition. Thus, considering the discussions about the role of emerging states in the international sphere, we selected for this study two emerging countries, namely Brazil and China, which are among the main developers and consumers of renewable energy in the world (IRENA, 2015).

In this context, we have two distinct realities. Brazil, for example, is in a relatively favorable position compared to OECD countries, with an energy matrix largely composed of hydroelectricity and other renewable sources, recent carbonization, contrary to international trends. While China, despite being a highly polluting emerging country, is showing signs of compressing the severity of the crisis we are going through and apparently developing its energy science for the challenges of the 21st century.

Energy consumption in Brazil and China

Today, Brazil is the ninth largest net energy producer in the world and the eighth largest consumer in the world. As shown in the chart below, Total Primary Energy Supply (TPES) stood at 298 Mtoe in 2015, with a significant share of renewable energy production such as biofuels and biomass, hydroelectric, geothermal, solar and wind.

Chart 2 – Total primary energy supply (TPES) – Brazil, 2015

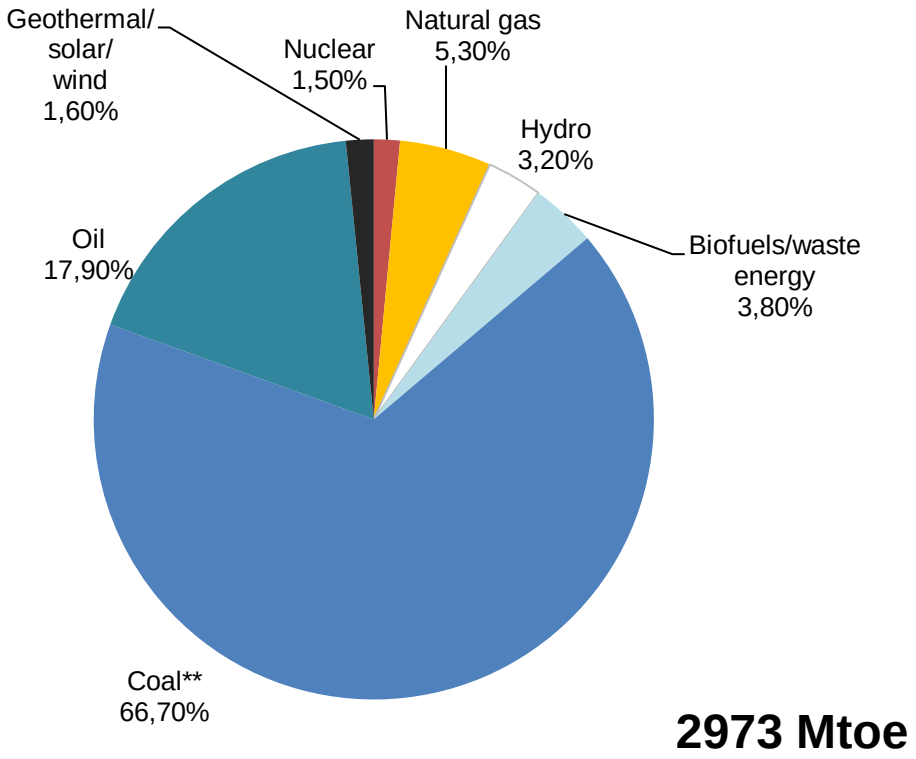


Own elaboration based in data from OCDE/IEA (2017).

Fossil fuels, especially oil and gas, have a significant share in the Brazilian TPES, although smaller compared to the other BRICS. Recently, the country has made significant discoveries of oil and gas: the so-called pre-salt. The domain of renewable energy, especially in the Brazilian electricity generation, brings some comfort in terms of security of supply thanks to the large use of hydro power, as well as the relationship between consumption, energy consumption and emissions. Some projects are showing success, as in the case of ethanol and biodiesel, and we are started to mature in wind generation, and we are also growing in photovoltaic solar energy, still counted in MW.

On the Chinese case, we have a pretty different picture. As we can see on the Chart 3 below, total primary energy supply (TPES) was 2973 Mtoe in 2015, demonstrating a high dependence on coal as the main source of energy, followed by oil and natural gas production.

Chart 3 – Total primary energy supply (TPES) – China, 2015



Own elaboration based in data from OCDE/IEA (2017).

China is the most populous country in the world (1.36 billion people in 2013) and has a fast-growing economy that has boosted the country's high global energy demand and energy demand (WB, 2015). In 2011, the country became the world's largest energy consumer and today is the world's second largest oil consumer behind the United States alone. The country was an oil exporter until the early 1990s, but according to the US

Energy Information Administration (EIA), it became the world's largest net importer of oil and other liquids in 2013. Growth in oil consumption in China represented about 43% of world oil consumption growth in 2014.

In March 2013, Xi Jinping became president and Li Keqiang took over as prime minister. The new administration has embarked on economic and financial reform in the country, with greater emphasis on long-term sustainable growth. In the energy sector, the government is moving toward market prices, energy efficiency and pollution control measures and competition among energy companies, as well as making greater investments in hydrocarbon areas and technically more challenging renewable energy projects.

The Chinese government has set the goal of increasing energy consumption from non-fossil fuels to 15% of the energy mix by 2020 and to 20% by 2030 in an effort to ease the country's dependence on coal. In addition, China is currently increasing the use of natural gas to replace petroleum and coal with a fossil burning fuel and plans to use natural gas for 10% of its energy consumption by 2020 (WNN, 2014). With China's goal of increasing energy efficiency and increasing environmental sustainability, coal's share of the economy is likely to decline.

The Chinese are already suffering the costs of a highly polluting, environmentally damaging coal-fueled economy to human health. The country is the world's largest producer, consumer and importer of coal and accounts for nearly half of the world's coal consumption, a major factor in global carbon dioxide emissions. In addition, it consumes much more oil than it can produce, and thus has obvious vulnerability in terms of energy security.

While coal should remain the mainstay of the electric power industry, the government shows that it wants to decarbonize the economy and look for new options to ensure its energy security. Aware of this, the country aims to become a world leader in clean energy by the year of 2030 (IRENA, 2014), and today has already the largest installed capacity of wind energy.

Regarding the emissions associated with energy consumption in the countries in question, Viola and Basso (2016), point out that while Chinese emissions are largely related to the burning of fossil fuels, especially in the production of electricity, in Brazil the great villain for GHG

increase is deforestation. In any case, the same authors admit that emissions from energy consumption, especially in recent times when deforestation has declined, have accounted for a considerable share of emissions, increasing their contribution.

About the Brazilian case, experts such as Ferraz (2017) argue the need for a reform of the organization of the Brazilian Electric Sector (SEB), characterized, according to her, by high prices and high risks of supply disruption. The same author also points out that the system has failed to increase the share of renewables in the electricity matrix, as we can see in graph 11 above, which shows a decline from 88% to 75% of the share of renewables in the Brazilian electricity matrix for the year. period between 2004 and 2014. Thus, it can be seen that Brazil has been going against the world trend, carbonizing its electrical matrix.

Ferraz also points out that some trends related to the energy transition are consolidated around the world, but Brazil still does not have adequate regulation for them. In this sense, the prosumers (professional consumers) and their possibility of off-grid generation deserve attention, which with the use of stocking technologies may dispense with the distribution companies and the network, the need for intelligent electric networks capable of better dealing with sources. intermittent, decentralization of these networks etc.

Mecanisms of incentive to renewable energy

Concerning to the energy market, generally, the use of new technologies is stimulated by the state in three ways: by the establishment of awards in tariffs, the so-called feed-in tariffs (FIT); by auctions, and; by a policy of quotes. These three strategies are used exclusively or combined, even with other incentives such as subsidies. These policies basically comprehend the neoclassical framework on economy, based on the idea of market failures. In a nutshell, they are allied to try to stablish a captive market to new and promising energy innovations and complement neoschumpeterian policies which aims to endogenize the innovation.

One of the mechanisms commonly used to encourage the development of new energy sources is the so-called feed-in tariffs (FIT), which consist of above-market special tariffs established for new sources offered through long-term contracts. Through a premium rate, the advent of new sources, such as wind and solar, is encouraged through contracts with terms capable of guaranteeing profitability and reducing risks to investors.

In some cases, FIT becomes progressively cheaper as a way to further encourage technological investments. This mechanism aims to make renewable sources competitive from price over traditional options such as fossil sources (ZAHNG, 2013). The mechanism is also useful even in the face of clean energy projects, such as large hydroelectric plants.

Another way of creating market reserve for new sources is through long-term renewal-specific bidding auctions, as auctions open to competition with traditional sources obviously tend to favor those sources that are already more developed and therefore they have lower financial cost and higher productivity. In any case, a policy of stimulating renewables presupposes concern with higher costs than financial, such as environmental and social costs.

Thus, the regulator sets a quota of KWh to be contracted, and offers are accepted in ascending order of price, contracting the cheapest projects in dispute, as many as necessary until supplying the initially established quota. This incentive mechanism, in order to be successful in stimulating business in the sector, must rely on auctions with certain regularity and predictability as to its compliance.

Finally, an alternative that has been increasingly used to encourage the development and consumption of new energy sources is the quota system. In this case, prices are borne by the market, but the law stipulates percentages (quotas) of production and consumption of certain renewable sources. Thus, agents either produce or contract energy from independent producers in long-term contracts. Another option is the acquisition of certificates from other agents that have proven to reduce their emissions beyond the established quota.

In these three models, the basic question to be answered is: who pays the bill?. In this case, costs are frequently transferred to the final consumer, whether splitting local costs locally or nationally. Anyhow, the challenge is to invest in innovation in the renewable energy sector, achieving the lowest prices and the best performance.

In the Brazilian case, the use of the feed-in-tariffs system has recently been instituted through the Programa de Incentivo às Fontes Alternativas de Energia Elétrica (Proinfa), which included projects for small hydroelectric plants, wind power plants and biomass-powered thermoelectric projects. Proinfa's contracts reached the expected initial

quota (of 3,300 MW capacity) and the second phase of the project did not start operations. This program did not included solar energy among the chosen sources. Proinfa also stipulated some requirements, such as national content. In the first step, the minimum requirement was 60%m national content and, in the second, it would be 90%. Despite the challenges in encouraging national content, especially for the formation of Brazilian companies in the sector and not foreign affiliates, the program nevertheless played an important role in diversifying energy sources in Brazil.

More recently, in Brazil, the feed-in-tarrifs system has given way to the auction mechanism within the so-called Ambiente de Contratação regulada – ACR (a regulated trading environment) since 2004. This market segment serves the purchase and sale of electricity, generally preceded by of bidding.

In China, on the other hand, since 1994, the government has made use of feed-in tariffs to encourage renewable energy. This policy is linked to the early years of wind energy development in the country and then to the promotion of photovoltaic solar energy. In any case, a more decisive boost from the Asian country came in the 2000s, when large areas favorable to wind projects were granted, with due financial support to investors, hiring guarantees, favored connection and other advantages.

On several fronts, the Chinese state has set itself the goal of implementing a strategy for the diffusion of these technologies, as a way of guaranteeing scale to its nascent industry in the sector, combining the requirement of national content with great incentives in research and development, encouraging the integration of business research institutes (LEWIS, 2013).

In this sense, the five-year plans have contributed to reducing emissions - at least in relation to a status quo scenario of Chinese energy and environmental policies - by following three basic determinants: the economic growth rate, the industrial structure and the energy structure.

That is, not only was generation and consumption stimulated, but there was always the prospect of forging a leading industry in the wind and solar sectors, capable of exporting and being globally competitive. In this sense, the Renewable Energy Law (LER) of 2005, and the medium- and long-term national development plans for the sector,

stipulated in 2007, constitute decisive milestones for the formation of the sector in the country.

Recently, China has made a new option by adopting the planned quota system. In this regard, it is planned that each of the Chinese provinces will be responsible for ensuring that a percentage of between two and ten per cent of its electricity consumption comes from renewable non-hydro sources, mainly wind, solar and biomass.

In this sense, provinces that are unable to meet their quotas may even have to suspend or reduce their fossil fuel power generation projects. On the other hand, recently distributed generation, when it is allowed and stimulated that consumers can generate their own electricity, has become attractive, especially for industry and the service sector, which have subsidies for the next twenty years.

Wind energy

Since the mid-2000s, wind power has been spreading more vigorously around the world, with increasing productivity, efficiency and cost savings. Today, wind power is already a competitive option and in 2016 it was close to 500,000MW installed worldwide, according to GWEC (2016).

In some countries, wind energy already makes an important contribution to the electricity matrix, as in the case of Denmark, where wind power accounts for over 40% of the country's generation. At the same time, wind power accounts for over 23% of generation in Portugal and Ireland, 20% in Uruguay, 19% in Spain and 15% in Germany.

Even so, larger and more populous countries lead in active installations around the world, although in these cases the wind source has less weight in their electrical matrices. China leads the industry in the world with 34.7% of installed capacity, followed by the United States and Germany. India ranks fourth with 5.9% of wind power facilities. Brazil participates with only 2.2% of the facilities.

It is also necessary to point out the very small participation of countries outside the Top 10, with all the other countries of the globe representing only 15.5% of the global wind energy installations, while the main countries in the field concentrate 84% of the total. at the same time indicating a high concentration of these investments as well as a great potential to be exploited.

In Brazil, a fundamental impetus for the development of wind energy occurred in 2006, when the first generators contracted at Proinfa and the reserve auctions began operating in 2009. Its installed capacity has been growing, although the number of new installations varies significantly each year, which in 2017 reached 12,966.7 MV. The capacity factor, which represents the use of wind to generate energy considering the relationship between the generated GWh and the installed power over time, also continued to increase in Brazil, as in the case of productivity gains around the world.

The performance of the capacity factor is the result of successive increases in facility size, accompanied by technological development, and the choice of better facility locations with more favorable winds (MME, 2016). According to the Decennial Plan for Energy Expansion - PDE2024, the target for 2024 is to reach 24GW of installed capacity, which seems ambitious considering the projection of the Brazilian Wind Energy Association (ABEEólica).

Solar energy

China has been successful in greatly increasing its installed and wind power capacity as a result of sound policies aimed at creating not only a consumer market for these energies but also its own export industry, initially with a clear objective of take advantage of the demand from European countries that have advanced by regulating the economy towards the use of less environmentally harmful energy alternatives.

The volume of investments made by China is impressive: in 2016, the country totaled US $ 78.3 billion! Most of them, about US $ 74.9 billion, for solar and wind sources. Among the other BRICS, in the same year, India also made considerable investments, also somewhat balanced between solar and wind sources, and Brazil presented significant investments in wind energy, as shown in table 5 below:

Table 1- Investment in renewable energy in China, India and Brazil, by sector in 2016 - $BN

	China	Índia	Brasil
Solar	**39.9**	**5.5**	**1.0**
Wind	**35.0**	**3.8**	**5.4**

Biofuels	**0.1**	**0.0**	**0.4**
Geothermal	**0.0**	**0.0**	**0.0**
Biomass & waste	**0.7**	**0.1**	**0.0**
Small hydro	**2.6**	**0.3**	**0.1**
Marine	**0.0**	**0.0**	**0.0**
Total	**78.3**	**9.7**	**6.8**

Own elaboration based in data from: McCrone et al., 2016.

In Brazil, its use does not grow to the same extent as the Chinese indices (see graph 26), and this source still has its contribution counted only in megavolts (MV), although there is great potential for expansion for both concentrated generation and distributed generation, for example. example by stimulating the cooperative model widely adopted among the Germans.

Again, this is one of those cases in which Brazil's natural potential is huge, yet we have failed to convert it into real gains. Brazil has excellent levels of solar irradiation, an essential precondition for massive investments in this technological option, superior to European countries, especially in the use of solar PV, as in the case of Germany, France and Spain.

In this way we can summarize the cases as follows:

China is making great efforts to adopt an energy security strategy that significantly targets renewable sources, or at least decisively points in that direction, and towards decarbonization, either by shifting towards a service economy or by forging. a cutting-edge industry based on low carbon technologies, which is also a big consumer. Still, the Asian country remains a leader among issuers and should remain so for a long time, even if it makes relevant policy decisions to the contrary.

In the case of Brazil, regarding the low carbon technologies analyzed, by not investing and articulating itself in promoting innovations in clean energy, taking the available market as an advantage, the country abdicates the possibility of technologically leading this promising sector and in tune with contemporary values, and continues to neglect sources with the potential to diversify its energy matrix, promoting greater security and decarbonizing its economy.

Conclusion

As we observed through our brief explanation, generally, China and Brazil made use of similar strategies such as feed-in tariffs (FIT), auctions and quotes to boost their consume of clean energy, from new technological solutions on wind and solar. Despite

this fact, China did it in a greater volume and has been way more consistent along the time. In addition, the Asian country have been treating the question well not only in terms of policies to supply their domestic demand, but policies to promote innovations to export (export driver), are at the core of Chinese energy strategy since the beginning and took advantage of a European legislation favorable to it. This strategy has been proved to be the right one, also if we consider the creation of a non-dependent energy sector, something is strategical as the history shows us.

Contrasting with the rigid Chinese planning, Brazil have cases of cancelled energy auctions just days before the scheduled, and despite a relatively success on the stimulation of on-grid wind energy is far from doing the same with solar energy. Indeed, when we talk about off-grid, a category more suitable to many solar enterprises, recently the government have been talking about taxing off-grid production, definitely threatening this activity to become unviable for most of the people.

In the course of our research, we have found many evidences regarding to the fact that although China is a highly polluting country, especially because of its energy matrix composed mainly by coal and other fossil fuels, at the same time it has strongly stimulated the renewables solutions considered here in the past decades, forming a prosperous and innovative national industry on renewable energy that plays at the cutting edge of the advances in the area which also helps to transform the energy consumption in the country.

As a result, China already constituted an entire industry on green energy and are at the cutting edge of the advances in areas like smart grid, thanks to edgy political economic planning consistent through the time. Meanwhile, the Brazilian recent trajectory is pretty much the opposite, marked mainly by a lack of structural policies, investments, and constancy of both of them, with relatively poor attention to the green energy sector in general. This occurs even if we consider the update of their grid, when simultaneously China have now leading enterprises on smart-grid, becoming ready for the future. These movements, occurred in a time when Brazil observed a carbonization of its energy matrix, still considered one of the cleaner in the world, threatened to be dependent of technologies that the country don't produce in the long term. China, at the same time, one of the top polluters in the world, rapidly became an innovation leader in green technologies and, despite their dirty energy matrix, seems to want to change it.

Notas

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