The Non-Decarbonization Puzzle in Brazilian Energy Policy

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The Brazilian economy is not decarbonizing and current policies are highly unlikely to change this. Expanding and diversifying the supply of renewable energy would improve price stability and enhance energy supply and access. Why do Brazilian governments adopt policy objectives and instruments which forego the significant benefits available from ambitious decarbonization objectives, and how can we explain differences across sectors? We analyze objectives and instruments in hydropower, transport fuels, solar- and wind energy. With the exception of hydropower, we find that the principle barrier to decarbonization are policy inconsistencies. In solar and, to a lesser extent, wind energy, national content requirements, a lack of R&D subsidies for building up domestic manufacturing capacities as well as the design of electricity auctions have stymied expansion. In transport fuels, the combination of inconsistent fiscal incentives and a price cap on gasoline have weakened the bioethanol sector in recent years. Emissions from the energy system are on a long-term upwards trajectory, present policies also limit Brazil's ability to contribute to global mitigation efforts.

1. Introduction

The Brazilian energy system is one of the cleanest in the world, yet the country is not on a decarbonization pathway. From the early 1990s until today, emissions from the energy system have roughly doubled, driven by population- and economic growth, growing demand for transport fuel and an increasing reliance on natural gas. Yet there is a distinctive lack of adequate public policies for the expansion and diversification of renewable energies. This is astounding, as numerous co-benefits would, in principle, be available from such policies: off-grid solar energy could contribute to electrification in those regions not connected to the transmission infrastructure; the availability of solar resources is synchronous with electricity demand due to the high prevalence of air conditioners; wind resources concentrate in structurally-weak regions where an expansion of wind energy could contribute to socioeconomic development; the availability of both wind and solar is countercyclical to the availability of water energy; expanding biofuels production would contribute to satisfying the increasing fuel demand; and, finally, different types of renewables are geographically complementary, with large wind resources being concentrated in the North-Eastern region, bioenergy from bagasse in the South-East and the largest untapped hydroelectric resources in the North. Moreover, unlike in most other countries, intermittency does not pose a problem as large hydropower reservoirs are able to supply sufficient baseload power to counterbalance peaks in demand (i.e. WRI 2015).

The expansion and diversification of Brazil's renewable energies would thus contribute in multiple ways to non-climate policy objectives, including economic development and energy security. Yet existing policy objectives are inadequate and make use of sometimes inconsistent instruments. This situation is reflected at the international level, where Brazil's commitments under both the Copenhagen Accord and the Paris Agreement were largely limited to curbing emissions from deforestation. Beyond foregoing co-benefits at the domestic level, the timid energy policy also weakens Brazil's diplomatic position internationally. Considering its self-understanding as a diplomatic leader among the countries of the Global South, particularly in the area of sustainable development, the gap between rhetoric and ambition is problematic.

Given those circumstances, why is it that the existing policy objectives and instruments are not up to task? Moreover, how can we explain differences in objectives and instruments across different types of renewable energies? In this paper, we focus on the solar-, wind-, hydro- and biofuels sectors. We argue that those sectors differ in terms of the gap between capacities and actual policies. Our case studies suggest that the primary explanatory factor is a lack of climate policy integration and, accordingly, the existence of numerous inconsistencies. In wind- and solar energy, national content requirements as a form of industrial policy create bottlenecks in the supply chains, thus hampering greater expansion. However, the greater availability of domestic production capacities for wind turbine equipment than for solar cells implies that the chilling effect of content requirements is smaller in the former than in the latter case. Fuel policy is similarly marred by inconsistent policies which have in recent years weakened Ethanol production. In large hydro power, finally, the gap between policies and capacities is the lowest of all the cases under consideration. This is due to the influence of entrenched interest groups adept at capturing public subsidies. We argue that, overall, the major structural factor inhibiting the diversification and expansion of renewable energies in Brazil are fossil fuel subsidies which have been rising constantly over the last two decades, while subsidies for renewable energies are predominantly geared towards large hydropower.

Section 2 provides a brief overview of the Brazilian emissions profile and the relevant domestic policies and instruments. Sections 3 to 6 deal with hydropower, ethanol, wind- and solar energy, respectively. Section 7 concludes.

2. Emissions, objectives and instruments

In this section, we first give an overview of the changing Brazilian emissions profile and the challenges it poses for energy- and climate policy. While emissions from the forestry sector have drastically declined in recent years, energy-related emissions have more than doubled since the early 1990s. At the same time, Brazilian governments have not committed to ambitious decarbonization targets. Where quantified targets exist, those are largely in line with business as usual. In terms of cross-cutting policy instruments for expanding and diversifying the supply of renewable energies, Brazil has mainly been relying on an auction system which possesses several flaws. Finally, subsidies are overwhelmingly geared towards fossil fuels, limiting the amount of resources available for renewables.

2.1 Energy and emissions

The Brazilian energy system is historically one of the cleanest in the world. However, economic growth is not decoupling from greenhouse gas emissions. Both the Brazilian carbon intensity and energy intensity are, today, at roughly the same level as in the early 1990s (EIA, source). Moreover, the share of renewables in primary energy production is in long-term decline (figure 1).

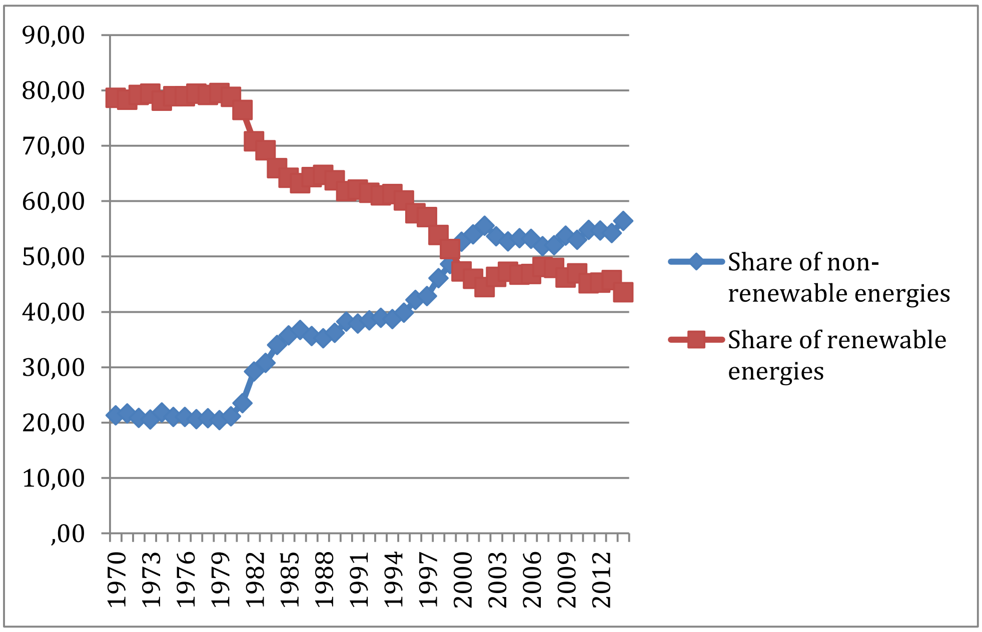

Figure 1: Renewable- and non-renewable energies, 1970-2014, based on MMA, xx

The present numbers still compare favorably to other industrialized- and emerging economies. Moreover, with 6% compound growth between 1990 and 2012, Brazilian greenhouse gas emissions have also been rising relatively slowly, presently amounting to about 1.4 $GtCO_2e$ per annum. Yet this trend obscures a fundamental shift in the overall emissions profile (figure 2).

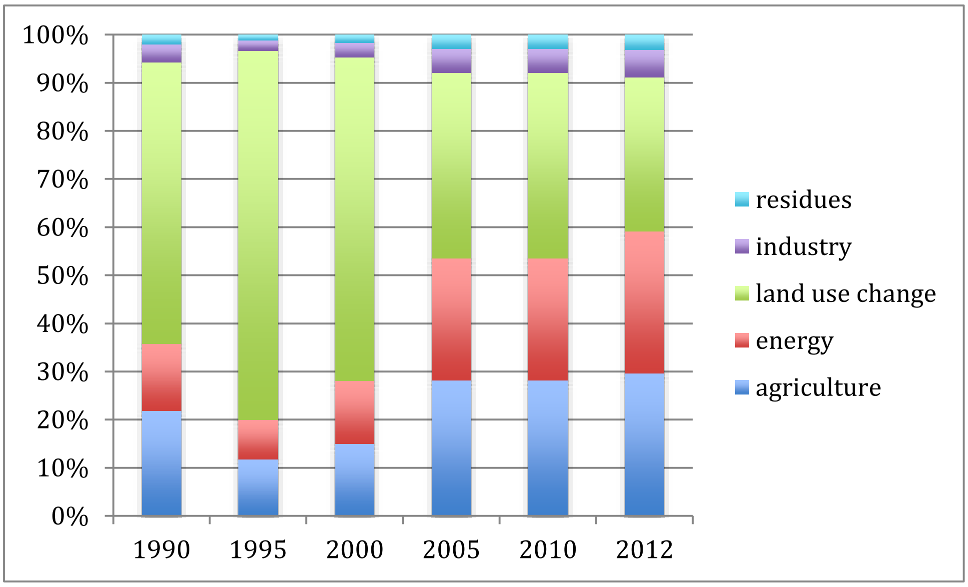

Figure 2: Sources of Brazilian greenhouse gas emissions, based on SEEG (2013)

As figure 2 shows, emissions from land-use change, particularly deforestation in the Amazonas region, are gradually giving way to other sources, particularly energy and agriculture. Since 1990, absolute emissions from both sectors have roughly doubled. While coal is largely irrelevant in the Brazilian context, the shares of gas and petroleum in primary energy production have been on an upwards trajectory since 1970. As the expansion of the domestic energy supply lags behind the growth in demand, natural gas imports have risen sharply since the mid-1990s, almost tripling to 7.1% of total energy consumption in 2014. The discovery of up to 50 billion barrels of pre-salt oil in Brazil's continental shelf ensures that production will remain high for the foreseeable future, given a suitable macro-economic environment. Conversely, the production of hydropower and energy from sugar cane-derivatives (bioethanol and bagasse) has remained largely constant since the 1980s. Whereas wind energy and small hydro have been gradually expanding in recent years, solar energy is practically inexistent.

With growing production and consumption of fossil fuels, it has been projected that, from 2020 onwards, "Brazil will be in a situation that is more similar to that of other industrialized countries, facing a new challenge of economic development with low-GHG energy-related emissions" (La Rovere et al. 2013: 84). Despite the critical importance of those latter emissions, domestic mitigation actions are still largely limited to the forestry sector. As the overall relevance of emissions from land-use change further decreases, this approach will increasingly become inefficacious. While forest conservation enjoys broad public support and has little impact on economic development, Brazil's future role in international climate policy depends on the extent to which energy systems and agriculture will be de-carbonized. Yet, public policies to tackle those challenges are presently woefully inadequate.

2.2 Domestic and international emissions targets

Brazil has put in place several key pieces of targets and instruments over the last decade. Those are not always fully consistent with each other. The 2008 National Plan on Climate Change (PNMC) formed the basis of the Brazilian Copenhagen pledge yet was limited to curbing deforestation (PNMC 2008). The 2009 National Policy on Climate Change set a voluntary target of 36.1% to 38.9% emissions reductions from Business As Usual (BAU) until 2020. Decree 7,390 of 2010, implementing the PNMC, sets a BAU deviation target for the energy sector by 234 $MtCO_2e$ to 634 $MtCO_2e$ by 2020. Brazil's 2010 communication of its Nationally Appropriate Mitigation Actions further specified those reductions: between 79 to 99 $MtCO_2e$ from the increased use of hydroelectricity; 26 to 33 from "alternative" energy sources (i.e. wind, solar and small hydro), 48 to 60 from increased use of biofuels and 12 to 15 from increases to energy efficiency (UNFCCC 2011: 8).[1] Curiously, those numbers do not add up to the overall reduction target given under Decree 7,390.

The Brazilian Nationally-Determined Contribution (NDC) to the 2015 Paris Agreement to the UNFCCC foresees emissions reductions of 37% by 2025 relative to 2005. While the adoption of an absolute target is remarkable, the sectoral policy objectives are largely in line with business-as-usual. The NDC seeks to increase the share of sustainable biofuels to 18%; achieve a 45% share of renewables, including by expanding non-hydropower renewables in the primary energy supply to between 28% and 33% and to 23% in electricity generation; and a 10% improvement to energy efficiency. The 45% renewables target by 2030 goes only slightly beyond the 43,5% renewables share in 2014, and the lower bound of the non-hydropower renewables

[1] While intended to comply with the Copenhagen Accord, Brazil's Nationally Appropriate Mitigation Actions have not been formally to it.

target as well as the 18% biofuels target have already been achieved as of 2014; (EPE 2015: 18).

Finally, the present, annually updated 10-year plan for energy expansion up to 2024 aims at an overall renewables target in the energy supply of 45,2% and a non-hydro renewables target of 31,9%. The share of energy supply from sugar-cane derivatives, which includes electricity generation from bagasse, is to expand to 16.9% (MME 2015: 436). Table 1 summarizes.

	2014	2020 NAMA target	2015-2024 Plan for energy expansion	2025 / 2030 Paris target
Renewables in primary energy supply	43,5% share	153 to 192 $MtCO_2e$ BAU deviation	45,2%	45% share
Non-hydropower renewables in primary energy supply	27.9% share	26 to 33 $MtCO_2$ BAU deviation	31,9%	28%-33% share
Use of biofuels in energy mix	18% share (incl. bagasse)	48 to 60 $MtCO_2e$ BAU deviation	16.9% (incl. bagasse, excl. biodiesel)	18% share

Table 1: Brazilian renewables targets under Copenhagen, Paris and the 10-year plan for energy expansion

2.3 Instruments

Biofuels and large hydropower in Brazil date back to the 1970s. The first major initiative for the expansion of other renewables was the 2002 *Programa de Incentivo às Fontes Alternativas de Energia Elétrica* (PROINFA). After a country-wide drought in 2001 exposed the weaknesses of over-reliance on large hydropower, PROINFA was to expand the installed capacity in wind-, bioenergy and small hydropower by 1100 MW respectively, by 2008. Originally making use of Feed-in Tariffs under the Cardoso administration, the program was re-structured to be based on auctions when Lula took office in 2003. PROINFA incorporated a national content requirement which was increased from 50% to 60% under the Lula administration. In the program's second phase, which was never implemented, this requirement was supposed to increase to

90%. The reasoning was that the economic benefits of localizing the manufacture and assembly of relevant technologies would offset their costs in the long run.

Notably, PROINFA did not contain a mandate for solar energy. The auctioning of power purchase agreements continued even after the program ended. Since 2007, 21 technology-specific auctions geared towards renewable energies were held, some of which included successful tenders for solar energy. Wind energy, with 13600 MW, accounts for the largest contract volume awarded, followed by biomass (4500 MW) and small- as well as large hydropower (2770 MW in total).[2] After the Brazilian government raised the price cap to attract foreign bidders, two auctions in 2015 resulted in contracts being awarded for the supply of 1.8 GW of solar energy. In the non-specific auctions, wind power has at times been able to successfully compete with natural gas-fired thermal power plants; however, this has not been the case for solar energy (Luomi 2014: 22).

The post-PROINFA auctions do not have mandatory national content requirements. However, access to subsidized BNDES credits are contingent on localizing certain shares of production and / or assembly. Those requirements are increasingly being ratcheted up. This is a problem insofar that Brazil does not possess sufficient domestic capacities for producing high-tech components for wind turbines or solar cells. Another issue is that firms must legally commit to generating a certain amount of energy annually, with shortfalls being penalized. Particularly for wind energy, where forecasting is difficult, this introduces significant economic uncertainties.

Numerous other instruments have been introduced in the last years. Some of those are sectoral in nature and will be discussed in more detail in the case studies. The *Inova Energia* programme of 2013 covers up to 90% of project costs for smart grids, hybrid vehicles and energy efficiency in transport. The program has a volume of R$ 3 billion (≈US$ 850 million) and is financed jointly by the BNDES, ANEEL and the Brazilian Innovation Agency (FINEP).

Numerous tax exemptions apply to renewable energies, including for imported technologies (IRENA 2015). Under the *Luz para Todos* (Light for all) program of 2003,

[2] Based on http://www.iea.org/policiesandmeasures/pams/brazil/name-146121-en.php

the government finances up to 85% of project costs for expanding renewable energies in underdeveloped rural areas. The 10-year plan for energy expansion foresees investments into renewable energy installations in the order of R$ 229 billion (≈US$ 64 billion) with R$ 155.8 billion intended for small hydro, wind, solar and biomass (MME 2015: 119).

In parallel to public policies designed to expand and diversify renewable energies, subsidies for fossil fuels are substantial and growing. Those include, for instance, tax benefits such as for infrastructure development in the North, North-East and Central-west regions; exemptions from import taxes for goods for oil- and gas-related research and extraction; and tax exemptions for coal- and gas power plants' fuel costs. While overall volumes of subsidies are notoriously hard to estimate, a recent study estimates those annual fossil fuel subsidies for which data is available at close to US$ 5 billion (ODI 2015). The OECD presently lists 12 programs which create tax exemptions or are directly funding fossil energies, most of which are on an upwards trajectory.[3] As a share of total subsidies, support for renewables numbers in the single digits and is overwhelmingly directed towards hydropower (Greenpeace 2013: 21-23). Table 2 summarizes the major financial transfers and tax incentives for renewables and fossil fuels.

	Programme	Volume
non-renewables	Fuel Consumption Fund	R$ 5 billion in 2015
	Energy Development Fund	R$ 1 billion in 2014
	National Plan for Research and Development in the Oil and Gas Sector	R$ 2,5 billion in 2014
	PIS/COFINS fuel tax reductions	R$ 35.2 billion in 2014
	REPENEC	R$ 198 million in 2014
	REPEX	R$ 1.5 billion in 2014
	CIDE	R$ 12.1 billion in 2014
	tax reductions for import and retail sale of naphta	R$ 1.9 billion in 2014
	Tax exemptions for coal and gas used in electricity generation	R$ 109 million in 2014
	REPETRO	R$ 8.6 billion in 2014

[3] see http://stats.oecd.org/Index.aspx?DataSetCode=FFS_BRA

renewables	Investments into renewable energy installations	R$ 229 billion in 2015-2024
	Inova Energia	R$ 3 billion in 2013 to 2016
	Luz para Todos	R$ 7 billion from 2003 to 2008

Table 2: Compilation of subsidies, sources: ODI (2015); OECD and IEA[4]

2.4 The non-decarbonization puzzle

The general picture which emerges is thus that, while energy-related emissions have increased dramatically over the last two decades and are bound to grow further, public policies are presently not up to task. Policy objectives for the Brazilian energy system suffer from inconsistencies and long-term targets which either have already been achieved or will be achieved under business-as-usual in the short run. National content requirements under PROINFA and the BNDES subsidized credit scheme have acted as a deterrent for the expansion and diversification of renewable energies other than hydro due to a lack of domestic manufacturing capacities. Considering the low level of subsidies for renewables, it is not surprising that such capacities have been developing only slowly.

As will be further discussed below, substantial climate- and non-climate benefits would, in principle, be available through more ambitious policies. The extent to which those benefits are realized under actual policies varies strongly across the different sectors of the Brazilian energy system. In large hydropower, this gap is particularly narrow as little scope for expansion exists as of today. In transport fuels, the Brazilian bioethanol program is one of the most-successful ones in the world, yet has suffered in recent years due to a combination of policy choices and the decline of oil prices on the world market. In wind energy, some limited progress has been made in recent years while solar is, for practical purposes, inexistent. The following four sections attempt to explain the choice of objectives and instruments in those sectors.

[4] See http://stats.oecd.org/Index.aspx?DataSetCode=FFS_BRA and http://www.iea.org/policiesandmeasures/renewableenergy/?country=Brazil

3. Hydropower

The use of hydropower as a renewable energy source is deeply embedded in Brazil. For example, Brazil is a real giant in dam-building. By producing 36.9 Mtoe per year Brazil is only second to China which produces 61.4 Mtoe per year (WEC 2016). Depending on producing capacity, the Brazilian-Paraguayan Itaipu-Dam is the biggest dam worldwide along with China's Three Gorges Dam. And yet, Brazil's decades-long expertise with hydropower is not due to an enlightened environmental consciousness but to considerations of energy security and independency.

Brazil heavily depends on hydropower. Usually, between 70 and 80 per cent of the country's electricity generation derives from hydropower (IHA 2015: 38). Considering this high dependency, it is no surprise that the government under the recently impeached President Dilma Rousseff has been highly committed to hydropower with the objective of maintaining the current levels of hydropower production over the next ten years (MME/EPE 2015: 436). Maintaining current production levels also involves the building of new dams. And here, Brazilian hydropower becomes troubling. Brazil boasts more than 200 hydroelectric power plants ranging from small dams to mega-dams (ANEEL 2016). Almost all mega-dams in Brazil are located in the Amazon River basin, after the Nile River the second largest river on this planet. The Amazon River basin houses the largest remaining rainforest on this planet and is home to one third of all species, one fourth of all freshwater, one fifth of all forests of this planet and the natural habitat of around 200 indigenous communities (IHA 2015: 38; The Nature Conservancy n.d.).

It is in this region where the construction works of new dams occur, taking advantage of the huge river basins of the Amazon River's tributaries. Two examples are the dams of Belo Monte and São Luiz dos Tapajós corresponding to 68 per cent of all new dams in planning or construction (EPE 2015: 84). These two dams - the Belo Monte dam nearing completion and the Tapajós dam still in planning stage - in particular are highly controversial and have been accompanied by intense social protests in and outside of Brazil. The Tapajós is one of the largest tributaries of the Amazon River and connects the Amazon basin with the Cerrado region further south, another Brazilian biome rich in biodiversity. Given its size, the life of countless animals and plants along with indigenous communities depends on the river (Great Rivers Partnership 2012). The construction of this dam does not only threaten the rich biodiversity of the whole river basin but also risks destroying the Munduruku indigenous community with around 13,000 people (Douglas 2015). Notwithstanding the criticism from Brazilian and international civil society organizations and the Munduruku leaders regarding the severe social and environmental damage to be inflicted by the construction of the dam, the government plans to go ahead and auction the dam in the second half of 2016 (Borges 2015). And Brazil's ultraconservative Congress does everything to move the project forward in complete ignorance of the devastating social and environmental risks (Borges 2015). The example of Tapajós illustrates very well that the Brazilian government and Congress have not learned very much with the disaster of the Belo Monte dam.

The Belo Monte dam on the Xingu River is supposed to be the third-largest dam worldwide after the Three Gorges dam and the Itaipu dam, diverting the flow of the Xungu River and thus destroying the livelihood of around 25,000 indigenous people and the rich biodiversity found in the river basin. It was in 2004 under former president Lula da Silva that the government circumvented environmental regulations and authorized the construction of eighteen new dams, among them the Belo Monte dam (International Rivers n.d.). The construction work has been moved along for more than one decade amidst a loaded atmosphere of social protest, indigenous mobilization, lawsuits filed against the project, workers' strikes and court orders stopping the whole project (International Rivers n.d.). If this were not enough, the investigations in the context of the current "Car Wash" corruption scandal revealed that the 11 construction companies involved, most of them with no prior dam-building experience, paid altogether around R$150 million (appr. €37 million) to the government disguised as donations during the electoral campaigns of 2010, 2012 and 2014 (Cruz et al. 2016). To put it briefly, Belo Monte represents a prime example of the irresponsible, unsustainable and narrow-minded attitude of the government towards indigenous communities and the preservation of the Amazon rainforest and its rich biodiversity.

These examples make very clear that the environmental consciousness of the current government and the majority of politicians in Brazil's Congress is not highly developed. Dam-building is Brazil is still seen primarily as a fundamental element of the country's energy security and independence, not necessarily as a worthwhile contribution to environmental protection.

What about Brazil's showcase dam, the Itaipu dam on the Paraná River, built during the military dictatorship in the 1970s in a binational project involving Brazilians and Paraguayans. When tourists visit this wonder of engineering genius, which was erected in close proximity to the natural wonder of the Iguazú Falls, they are bombarded with the impressive facts and figures of Itaipu's energy production and efficiency and its environmental and social responsibility. After all, Itaipu produces 15 per cent of the energy used in Brazil and a staggering 75 per cent of the energy consumed in Paraguay (Itaipu n.d.). These figures and facts of Itaipu's clean energy production are based on a rather dirty history. The construction of Itaipu resulted in the devastation of wide stretches of the Atlantic Forest which includes the Sete Quedas Falls with seven large falls, a water fall hardly less impressive than the Iguazú Falls (Ziober et al. 2014: 60-61). By flooding an area of 1460 km², these falls along with forests, plants and the homes of around 65,000 indigenous people was lost forever (Ziober et al. 61). For Itaipú, environmental concerns have always been secondary to the prime objective of energy generation (Ziober et al. 2014: 67-72). Even those degraded areas which were in fact reforested served security reasons such as the establishment of a security zone around the power plant (Ziober et al. 2014: 70). The company also prides itself for having rescued several animal species before flooding their natural habitats. And again, the company was not at all interested in preserving the natural biodiversity found in these areas. Some animals were merely rescued from drowning, when the area was already being flooded, while a large majority of other animals did drown. And those that were rescued were pit into inadequate shelters (Ziober et al. 2014: 71-72).

To be sure, it would be quite naïve to expect any environmental consciousness of a military dictatorship in the 1970s. It is, however, highly worrying that more than forty years later, now in a democratic system, the logic of dam-building remains virtually unchanged in Brazil. This unchanged logic might come to haunt Brazil in the future, since the primary reason of energy security is not necessarily justified. First, all these major dams are fundamentally mismanaged in their construction stage creating huge overrun costs (Ansar et al. 2014). In the case of Belo Monte, the original costs of around R$16 billion have already skyrocketed to more than R$30 billion with no end in sight (Pereira 2013). The environmental damage committed by dams can have a severe impact on the energy production of these dams. The habitat loss and environmental degradation caused by the flooding of vast areas can result in droughts, savannaisation and lower river levels which in turn exacerbate global climate change and negatively affect the dam's energy production (Lees 2016).

4. Ethanol

The production of biofuels in form of sugar-cane based ethanol has a long tradition in Brazil, dating back to 1975 when Brazil's National Ethanol Program (ProÁlcool) was called into life. As in the case of hydropower, the then military dictatorship stimulated ethanol production for reasons of energy security. Initiated after the oil crisis of 1973, the military dictatorship sought to strengthen Brazil's traditionally string sugar market (Ferreira Simoes 2007: 19). After all, sugarcane profoundly shaped Brazil's society and economy for centuries, associated with the outraging atrocities of slavery and the shocking wealth of tiny elite of landowners (Schwartz 1984).

Brazil's production of sugarcane-based ethanol has experienced several ups and downs in the last few decades (Rosillo-Calle and Cortez 1998; Ferreira Simoes 2007). Notwithstanding several crises of the Ethanol Program, which was closely related to the recovery of the oil price, the focus on ethanol contributed to the emergence of a strong ethanol producing industry, a highly innovative research sector and several regulations legally entrenching the use of ethanol as fuel in Brazil (Rothkopf 2007; Belik and Feige 1998). In 1993, the federal government introduced a law making the mixture of ethanol and gasoline an obligation by setting the percentage of ethanol at 22 per cent (Lei N◦ 8.723, Art.9). Ethanol production returned on the political agenda of the federal government in 2003 with the newly elected president Lula da Silva making ethanol production a high priority. His government introduced the flex fuel motor making it possible for all cars in Brazil to either use gasoline, hydrated ethanol (curs exclusively run by ethanol) or a blend of gasoline and ethanol (Biodiesel 2013). In 2007, the government increased the obligatory percentage rate of ethanol in the gasoline-ethanol blend from the former 22 per cent to 25 per cent (Portaria N◦ 143). All these investments into ethanol production, accompanied by the political will of the federal government to entrench the use of ethanol-fueled cars in Brazil and the further development of the private sector has made Brazil a leading producer and exporter of sugarcane-based ethanol with the strongest industry and research sector on ethanol found in Brazil (Rothkopf 2007: 447; IEA 2006: 11).

The governments of Lula da Silva (2003-2010) and Dilma Rousseff (2011 – 2016) have also turned ethanol production into a major foreign policy issue praising the benefits of ethanol production in the fight against climate change and emphasizing its development potential for developing countries in the global south (Fraundorfer 2015: 144-147). By creating a powerful discourse embracing the environmental and social benefits of ethanol production and relying on its strong domestic market, Brazil has been successful in playing a significant role in several global governance mechanisms on biofuels. The most important mechanism is certainly the Global Bioenergy Partnership founded in 2006 to promote dialogue and cooperation on biofuels at the global level. Together with Italy, Brazil has been the co-chair of this partnership since 2008 (Fraundorfer 2015: 153; GBEP 2016). The GBEP represents the top forum on biofuels at the global level by uniting all important biofuel producing countries, international organisations and companies. Through its activities in working groups and task forces, Brazil has been able to use the GBEP as a platform to disseminate the expertise and knowledge of its own decades-long ethanol production and entrench it as a viable alternative to fossil fuels (Fraundorfer 2015: 153-156, 159). In the same vein, the Brazilian government has reinforced its cooperation with the US, Brazil's major rival in the production of ethanol, the EU and other biofuels producing countries (Fraundorfer 2015: 156-159).

As in the case of hydropower, the production of ethanol has repeatedly created controversies about its actual environmental and social benefits. Civil society organizations and scientists warn that the production of biofuels from food crops can have a tremendous environmental impact such as soil damage due the conversion of land from the cultivation of monocultures (Oxfam 2008; Fargione et al. 2008). Fargione et al. have found that Brazil's sugarcane-based ethanol is much more environmentally friendly than the US-based production of ethanol from corn or the production of ethanol. For instance, while sugarcane-based ethanol produced in Brazil's Cerrado region would take 17 years to offset the carbon debts generated during the production process, corn-based ethanol in the US takes between 48 and 93 years (Fargione et al. 2008: 1236). In Brazil, civil society actors argue that the production of ethanol indirectly threatens the Amazon rainforest by pushing cattle farming closer to the Amazon. In addition, many sugarcane plantations in the south and centre of Brazil are dangerously close to the Pantanal and located in the Cerrado, two other rich biomes

(UNICA 2008). So, the production of ethanol-based sugarcane is certainly not risk-free, particularly not if the main responsibility is with large corporations whose commercial interests trump environmental and social concerns. Therefore, it is not the least surprising that the Brazilian ethanol sector is riddled with scandals about slave labor, inhuman working conditions in production plants and other grave human rights violations (Mendonça 2009; Repórter Brasil 2010; Saragoussi 12 March 2013; Gomes 09 May 2013). The Sao Paulo Sugarcane Industry Association UNICA, a powerful association of ethanol producers in the State of Sao Paulo has tried to improve the image of the sector by introducing stricter environmental and social regulations (Fraundorfer 2015: 141-142). These activities may have somewhat improved the working conditions in the production plants. The social situation of many workers in ethanol production plants and plantations, however, remains worrying (Gomes 09 May 2013; Repórter Brasil 2011).

Due to the introduction of flex fuel vehicles, anhydrous ethanol (blended with gasoline) can be substituted by hydrous (pure) ethanol. The relative competitiveness of the two fuel types hinges on the price difference between ethanol and gasoline. Due to its lower energy density, the break-even price is reached when the former costs roughly 70% of the latter (Ackrill and Kay 2014: 40). Since 2010, the changes in the price ratio have had detrimental effects on ethanol consumption (IEA 2014: 45-46). The decrease in global oil prices and the recent increase in ethanol production costs, due to a combination of bad harvests and high sugar prices on the world market, implies that consumers tend to choose anhydrous over hydrous ethanol. Due to declining production, Brazil started importing ethanol from the US in 2011. Those problems are exacerbated by the recent introduction of a price cap on gasoline which observers have linked to attempts to control inflation as well as to appease the electorate prior to the 2014 presidential elections. Jointly, this creates disincentives to consume greater amounts of ethanol (Khanna et al. 2016).

Direct budgetary transfers have largely been slashed with the end of ProÁlcool in 1991 and the liberalization of the Brazilian fuel market throughout the 1990s (Ackrill and Kay 2014: 34-37). The CIDE tax which had included different rates for ethanol and gasoline and accounted for 95% of total subsidies for the latter in 2002-3, was abolished in 2012 and re-introduced, at a lower rate, in 2015. Combined with the price cap on gasoline, ethanol subsidies became negative in 2012 (Jales and da Costa 2014).

Presently, the primary policy instrument is thus the blending mandate for anhydrous ethanol.

5. Wind energy

Brazilian wind energy has expanded rapidly in the last years, from a generation of 29 MW in 2005 to 8715 MW in 2015. Wind resources are distributed unevenly, with the highest incidence in the Northeast and the South. Off-shore installations are presently not being considered due to prohibitive costs (MEA 2014: 8). Expanding the share of wind energy in the energy mix requires long-distance transmission, a problem which is exacerbated by the inadequate Brazilian grid. As the largest share of electricity is consumed in the South-East region, grid improvements are vital if Brazil is to increase its share of wind energy. The potential for wind energy is enormous and is estimated at 300 GW. According to one estimate, the expansion of wind energy to 10% of electricity generation by 2030 would entail welfare losses of merely 0.1% (Landis and Timilsina 2015). Moreover, Brazil has one of the world's lowest generation costs, surpassed only by China and India. As the largest wind resources concentrate in structurally-weak parts of the country, stronger investments would also contribute to greater socio-economic development.

The first government scheme to hike up wind energy was the PROEOLICA program of 2001, introduced after a country-wide drought had highlighted the risks of over-reliance on hydropower. Intended as an emergency measure to provide for 1050 MW of wind energy by 2003, PROEOLICA was a failure. Wind energy was subsequently integrated into the PROINFA initiative where it, at times, successfully competed against fossil fuels in non-technology specific auctions. With 1422 MW of capacity being added, the PROINFA targets for wind energy were actually overachieved.

Wind energy was subject to the mandatory national content requirement under PROINFA. As in solar, this created substantial bottlenecks as, when PROINFA was introduced, the only local company able to produce the requisite technology was the Danish manufacturer Vestas. Today, producers must equally satisfy the content requirement to obtain favorable BNDES credit. Those requirements have recently been ratcheted up. As of January 2014, the BNDES requires that certain turbine components (such as gearboxes, towers or blades) be manufactured or assembled in Brazil. From 2017, over 70% need to be produced locally (MEA 2014: 10-16). However, domestic capacities have been increasing in recent years as large numbers of European and North American manufacturers have entered the market (MEA 2014: 11-14).

6. Solar energy

Unlike for wind energy and hydropower, the distribution of solar irradiance is relatively homogenous throughout Brazil (Martins et al. 2007). While the availability of solar resources in Brazil is higher than in Europe, solar energy is “virtually inexistent” (Martins et al. 2007: 524). In fact, its share in the Brazilian energy matrix is so negligible that it is usually not even reported in official statistics and documents, including the 2007 National Plan on Climate Change. In 2011, installed capacity amounted to a meagre 5 MW out of a total capacity of 126.743 MW (MME 2014: 45). Yet, large potential exists for building-integrated photovoltaics in urban areas where the electricity demand curve peaks during day time due to the widespread use of air conditioning (Jardim et al. 2008). Off-grid solar energy would reduce losses from inefficient transmission and distribution. It would also offer significant advantages for the Amazonas region, large parts of which are not connected to the Brazilian grid, with diesel generators instead supplying most electricity (Martins et al. 2008). The seasonal availability of solar energy is also anticyclical to that of hydropower; expanding solar energy would thus counterbalance shortages during the summer and enhance the security of energy supply during particularly hot seasons.

The main barrier to expanding solar energy appears to lie in policy inconsistencies, in particular with the national content requirement as a form of industrial policy. Subsidized credit from the BNDES is only available for manufacturers which utilize domestically-manufactured solar modules. This constrains the capacity for solar development, as no such domestic manufacturing capacities currently exist. While Brazil is one of the world’s largest suppliers of metallurgical-grade silicon, it does not possess the requisite capacities for sufficient purification. As the silicon component, by itself, accounts for roughly 20% of final costs, the content requirement strongly limits the potential for expanding solar energy. Those content requirements will be ratcheted up over the coming years. Presently only covering solar panels, from 2018 onward, junction boxes, power inverters and supporting structures will equally need to be manufactured domestically.

However, the recent spike in power purchase agreements awarded to producers of solar energy suggests that several regulatory changes might create a more conducive environment for the expansion of solar energy. Since 2014, contracts have been granted for the development of 1750 MW of solar energy. Compared to a total electricity consumption of 516.2 TWh as of 2013, this is but a drop of the ocean. The situation might be changing, though, as several important changes have recently been implemented. For one, the government has raised the price caps in recent auctions, increasing the attractiveness of bidding. The recent introduction of solar-only auctions, two of which took place in October 2014 and August 2015, improves the capacity for expansion as solar need not compete with established (and cheaper) sources of energy, such as biomass or large-scale hydropower. The electricity regulation agency ANEEL has also reduced the red tape for net-metering. Presently, owners of small-scale (up to 5 MW) solar installations can offset their electricity bills by feeding excess electricity back into the grid, while still being barred from selling directly to third parties.[5] The ministry of mines and energy (MME) has introduced a tax incentives program in December 2015, which offers tax exemptions on electricity fed back to the grid and reduced import taxes for PV equipment from 14% to 2%. Since 2015, numerous Brazilian states created tax breaks for solar energy as well. Finally, solar energy has recently been included in the semi-conductor programme PADIS (Programa de apoio ao desenvolvimento tecnológico da indústria de semicondutores) which also offers numerous tax breaks.[6] On top of those regulatory changes, the Brazilian manufacturer Globo Brasil opened in August 2015 the country's first solar panel factory with a capacity of producing up to 2.000 solar panels per day.[7] With other factories in construction, this will enhance access to subsidized BNDES credits, as utilities will have an easier time in complying with the national content requirements.

[5] ANEEL resolution No. 687, November 2015
[6] PADIS is currently on hold, barring an extension
[7] See http://www.paineisglobobrasil.com.br/

7. Concluding Remarks

Our preliminary analysis highlights three factors which explain the insufficient expansion and diversification of renewables in Brazil. First, changes in the regulatory environment are highly erratic. Particularly the case of bioethanol and fuel taxation shows how Brazilian governments have resorted to ad hoc measures which complicate long-term investment decisions. Second, there is insufficient climate policy integration. Since the end of PROINFA, Brazil has lacked a centralized policy framework for renewables. Inconsistencies such as national content requirements without domestic manufacturing capacities have stymied the development of solar and, to a lesser extent, wind energy. Similarly, the price cap on gasoline may have contributed to inflation control and success at the ballot box yet has weakened the Brazilian ethanol sector. Third, tax incentives and direct budgetary transfers are overwhelmingly biased towards fossil fuels. This has had negative impacts on the ethanol sector where direct subsidies have largely been removed throughout the 1990s. In wind and solar, the volume of subsidies, such as under the Inova Energia programme, remain meagre and do not contribute to the expansion of those energy sources

It is clear why the Workers' Party (PT) governments have promoted hydropower and the production of sugarcane-based ethanol as its answer to the fight against climate change. Both hydropower and ethanol production are deeply embedded in Brazil with a powerful industry and decades-long expertise. Furthermore, as the unfolding "Car Wash" corruption scandal has illustrated the political elites in Brazil are deeply enmeshed with the economic elites. The PT has understood to transform this close relationship into an unprecedented art form by designing elaborate corruption schemes to be used for money laundering. The construction of the Belo Monte dam served this particular purpose where the federal government accepted irresponsible environmental damage and grave human rights violations against workers and local indigenous communities for the sake of mere energy security and electricity generation, not for the sake of the environment (Brum 2016). Lula da Silva during his time as president also downplayed the series of grave human rights violations in Brazil's ethanol sector and minimized the environmental risks involved in ethanol production for the sake of increased influence and power on the global stage, not for the sake of serious environmental concerns.

Internationally, insufficient policy objectives and inadequate (or even inconsistent) instruments weaken Brazil's diplomatic position in the post-Paris climate negotiations. The negligence of energy-related emissions in Brazil's NDC and the focus on the low-hanging fruit of emissions from land-use change and forestry highlights a distinct lack of ambition in contributing to global mitigation efforts (Fraundorfer and Rabitz 2015). This stands in stark contrast to Brazil's self-avowed leadership role among the countries of the global south in the international politics of sustainable development. Moreover, inconsistent and erractic policy-making, in conjunction with subsidies being biased towards fossil fuels and large hydro, foregoes significant co-benefits which would be available from a greater focus on non-hydro renewables.

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