Article:
Fraundorfer, M and Rabitz, F (2020) The Brazilian renewable energy policy framework: instrument design and coherence. Climate Policy, 20 (5). pp. 652-660. ISSN 1469-3062

https://doi.org/10.1080/14693062.2020.1754157

The Brazilian renewable energy policy framework:

Instrument design and coherence

Markus Fraundorfer

Lecturer in Global Governance

School of Politics and International Studies

University of Leeds

Email: m.fraundorfer@leeds.ac.uk

Florian Rabitz*

Senior Researcher

Research Group Civil Society and Sustainability

Kaunas University of Technology

Email: florian.rabitz@ktu.lt

*Corresponding author

Abstract

In the context of Brazil's rising energy-related greenhouse gas (GHG) emissions, we develop a forward-looking analysis of the domestic renewable energy policy framework. We probe the overall effectiveness of this framework by focusing on instrument design (in terms of stringency and predictability) as well as policy coherence. We analyze the development of solar, wind and hydropower, as well as biodiesel and ethanol, in the period between 2003 and 2018. We find strong increases in stringency for biodiesel, solar and wind power, marginal ones for ethanol, and decreasing ones for hydropower. Predictability presents a consistent challenge for policy effectiveness, with the exception of biodiesel. Overall policy coherence improves with fossil fuel subsidy reductions after 2014, although the complex environmental licensing regime as well as *ad hoc* fiscal interventions and price controls in the fuel markets create tensions for biofuels expansion. The policy framework as it has evolved through the period under consideration is neither likely to slow down/reverse the growth trend in natural gas consumption for power generation, nor to significantly alter the fuel mix in light-vehicle transportation. Considering that improvements in the policy framework are partially driven by non-climate rationales, we conclude that rising energy-related GHG emissions will increasingly challenge Brazil's contribution to international temperature targets while diminishing its stature in global climate diplomacy.

Key policy insights

- Renewable energy policies in Brazil suffer from a lack of predictability.
- While recent reductions in fossil fuel subsidies have improved policy coherence, significant incoherencies between policy instruments impede renewable energy expansion.
- Increasingly ambitious expansion targets for solar and wind power will need to close the supply gap resulting from the relative decline of hydropower in order to avoid further increases in natural gas consumption.
- Although the Bolsonaro administration has not created substantial policy changes so far, it introduces additional uncertainties regarding long-term decarbonization, while also diminishing Brazil's diplomatic stature in international negotiations.

Keywords: Brazil, renewables, energy policy, instrument design, policy coherence

1. Introduction

With its unique blend of biofuels and hydropower, the Brazilian energy system ranks among one of the cleanest in the world. Driven by concerns over energy security, the domestic hydropower and ethanol

sectors have expanded significantly since the 1970s, with environmental side-benefits becoming increasingly important since the 1990s (Leite 2009; Vieira and Dalgaard 2013). However, while Brazil frequently brandishes its clean energy credentials, energy-related greenhouse gas (GHG) emissions are trending upwards, increasing from 192 to 481 metric tons of carbon dioxide ($MtCO_2e$) between 1990 and 2014, before declining due to the contraction of the Brazilian economy. As a share of total emissions, energy-related emissions increased from 9 to 22% during that period (SEEG 2019). This trend is primarily driven by increasing consumption of oil products as well as natural gas (see figure 1). The expansion of low-carbon energy sources, including in electricity generation to counteract the rapid increase in the consumption of natural gas, will thus increasingly become a challenge for Brazilian climate policy (EPE 2019; La Rovere et al. 2013; Viola and Basso 2015). Its legacy renewables imply that Brazil "starts comparatively ahead of its peers", yet now "it is moving backwards" (Basso 2019: 17). Together with persistent problems in effectively controlling emissions from forestry and other land uses (Rochedo et al. 2018), this trend raises questions regarding Brazil's future contribution to global temperature targets under the 2015 Paris Agreement.

[Figure 1: Final energy consumption by source in million tons of oil equivalent (Mtoe), 1990 to 2018. Source: EPE (2019).]

The purpose of this paper is to assess the overall effectiveness of the Brazilian renewable energy policy framework by focusing on the design of individual policy instruments, as well as the broader instrument mix. In doing so, we derive broader expectations regarding Brazil's decarbonization prospects. While numerous high-quality studies address various aspects of Brazilian climate and energy policy, they overwhelmingly focus either on individual energy sources such as wind power (Dutra and Szklo 2008; Diógenes et al. 2019), solar photovoltaic (PV) (Rocha et al. 2017) or biofuels (Stattman et al. 2013; Nuñez and Önal 2016); or on the "big picture" of the politics of energy systems and decarbonization

(Vieira and Dalgaard 2013; Viola and Basso 2015; Basso 2019). Our paper attempts to occupy a middle ground by evaluating the effectiveness of public policies, in terms of instrument design and instrument mixes, in the context of the most important Brazilian renewable energy sources.

We analyze cross-sectoral and temporal variation in the decarbonization signal of Brazil's renewable energy policy instruments, as well as the noise arising from incoherencies in the wider instrument mix. This approach is based on two considerations. First, as socio-technical lock-in limits the prospects for endogenous change (Markard et al. 2012), the clean energy transition requires stringent and predictable policy signals in order to induce behavioural changes and build stable long-term expectations among economic actors (Kemp and Pontoglio 2011; Carley and Miller 2012; Skeete 2017). Second, Brazilian renewables form part of a wider socio-technical regime ridden with contradictions. Inconsistencies in the instrument mix potentially drown out the signal of renewable energy policies. Policy effectiveness thus also hinges on the degree to which disruptive interplay is being avoided (Jordan and Lenschow 2010; Nilsson et al. 2012). Reducing noise in the instrument mix is vital where sectoral policies have impacts that cut across policy domains and lead to differential impacts across different types of societal stakeholders.

As the primary determinants of renewable energy policy effectiveness, we analyze variation in instrument design (in terms of regulatory stringency and predictability) and policy consistency across energy sources. We identify relevant policy instruments by drawing on the IEA / IRENA Global Renewable Energy Joint Policies and Measures Database, the New Climate Institute's Climate Policy Database and the OECD Inventory of Support Measures for Fossil Fuels. We also include a range of strategic planning documents, such as the annual 10-year plan for energy expansion (*Plano Decenal de Expansão de Energia*, PDE), the National Climate Change Plan and the National Energy Plan (*Planos Nacionais de Energia*, PNE) for 2030. Our sectoral focus is on hydro, solar and wind power, as well as ethanol and

biodiesel. We thus exclude several renewable energy sources that are limited to specific sectoral applications (such as charcoal for pig iron production or bioelectricity from bagasse) or that presently have low scalability (such as H-bio or tidal energy).

Our time frame covers the administrations of Luiz Inácio Lula da Silva (2003-2010), Dilma Rousseff (2011-2016) and Michel Temer (2016-2018). We choose this period due to extensive reforms and changes in the energy sector, characterized by a broad range of interventionist measures and incentives that differ markedly with the market-liberal approach of the previous Cardoso administration (Leite 2009). During this period, Brazilian governments started diversifying the renewable power supply to reduce systemic risks associated with an overreliance on hydropower as well as to overcome political, social and environmental challenges associated with large dam construction (Douglas 2015; Cruz et al. 2016). As a consequence, Brazil turned into South America's largest wind power market with 14.4 GW of installed capacity, as well as a fledgling solar PV sector standing at 2.2 GW as of 2018 (IRENA 2019). In the fuel sector, Brazil became one of the world's largest producers of biodiesel since the introduction of its national biodiesel programme in 2007 (Stattman et al. 2013). Domestic ethanol production, meanwhile, has faced headwinds from price shocks in the global markets for agricultural commodities, price controls in the domestic gasoline market and insufficient access to credit, among other factors (Ackrill and Kay 2014: 34-37). While our analysis concludes with the end of the Temer administration in 2018, we briefly turn in the conclusions to the potential implications of the present administration of Jair Bolsonaro, which has so far refrained from introducing major policy changes in Brazilian climate and energy policy.

2. Renewable electricity

The Brazilian electricity system has seen significant changes in recent decades. Hydropower, the main pillar of domestic power production since the 1970s, has been declining in its share of domestic generating capacity, as conflicts over social and environmental impacts have stymied large dam construction since the 1990s. Between 1995 and 2002, the Cardoso administration unbundled electricity markets, privatized large parts of electricity distribution, and created a variety of new regulatory agencies, notably the regulatory agency for the electricity market (*Agência Nacional de Energia Elétrica*, ANEEL; Leite 2009). Cardoso's market-based model came under pressure when it failed to attract sufficient investments in generating capacity and a 2001-2002 drought exposed the vulnerabilities of the hydropower-based electricity system. Since the Lula administration took office in 2003, the electricity sector has been characterized by stronger state intervention and an ever-expanding policy portfolio intended to expand and diversify the renewable power supply. While hydropower continues its relative stagnation, wind power has expanded dramatically, presently accounting for 7.2% of the domestic electricity supply (EPE 2019). While solar power has seen substantial increases since 2017, its overall share in domestic supply is still low when compared to other emerging economies, accounting for 1.5% of installed capacity in 2018 (IRENA 2019).

2.1 Instrument design

Auctions, covering three quarters of the domestic electricity market, are the primary policy instrument for expanding and diversifying the renewable power supply since the Lula administration (Azuela et al. 2014). Auctions were initially introduced within the context of the *Programa de Incentivo às Fontes Alternativas de Energia Elétrica* (PROINFA), the first major instrument for expanding and diversifying

the renewable electricity supply, which was created under the Cardoso administration in 2002 and originally based on Feed-in Tariffs (Dutra and Szklo 2008; Aquila et al. 2017). Under the auction system, the market operator tenders electricity volumes based on the five-year demand forecasts of distribution companies, with contracts being awarded to those generation companies submitting the lowest bids (Losekann et al. 2013: 302). With substantial fluctuation in volumes and frequent cancellation of scheduled auctions, predictability is low.

In total, between 2005 and 2018, contracts were awarded for 25.2 GW of installed capacity in hydropower, 18 GW in wind power and 3.4 GW in solar power (ANEEL 2019), yet there is significant year-on-year variation. Close to half the total volume in large hydropower was contracted in 2009, with stagnation afterwards. Annual volumes for wind power vary between 0.28 GW (in 2012) and 4.7 GW (in 2013). In 2016, auctions for both wind and solar were cancelled due to downward adjustments in demand projections. In 2017, reverse auctions were introduced to prevent oversupply and to clear the market from projects with questionable feasibility. The unpredictability of the auction system is seen as a major impediment to investments in the sector (Diógenes et al. 2019: 260). Figure 2 illustrates the growth in installed capacities for wind, solar and hydropower between 2003 and 2018.

[Figure 2: installed capacities in wind, solar and hydropower, 2003-2018. Sources: EPE (2019) and IRENA (2019).]

Besides low overall predictability across all three renewable energy sources, we find increasing instrument stringency in solar and wind power, and decreasing stringency in hydropower. As tender volumes in the Brazilian auction system are tied to demand forecasts (with the exception of reserve auctions), they do not allow for meaningful inferences regarding stringency. However, for wind and solar power, we

find an increasing tendency towards technology-specific auctions. As the success of new energy technologies hinges on the extent to which regulatory authorities create and manage niches within a given technological regime (Kemp et al. 1998), such targeted support measures are indicative of increasing stringency. Wind and solar power have been included in technology-specific auctions since 2007, usually together with small hydropower (installations of <50 MW capacity) and bioelectricity. Reserve auctions specific to wind power were held in 2009 and 2013. Reserve auctions specific to solar power, as well as to solar and wind, took place in 2015.

Long-term policy planning also shows divergence between solar and wind power on the one hand, and hydropower on the other. Setting the 10-year indicative forward-planning under the annual Plans for Energy Expansion in relation to projected electricity demand, we see declining stringency (in terms of decreasing relative expansion targets over time) for hydropower, yet increases for wind and solar. The growing prioritization of non-hydro renewables over hydropower also manifests itself in the difference between the 2007 Energy Expansion Plan and Brazil's Nationally Determined Contribution (NDC) under the 2015 Paris Agreement, both with a time horizon of 2030: the former foresees an increase in the share of renewables other than hydropower, firewood, charcoal, sugarcane and sugarcane derivatives to 9.1% of the domestic energy supply, whereas the latter seeks to expand non-hydro renewables to a minimum of 23%.

2.2 Coherence

We identify three sources of incoherence that apply, in different ways, to the hydro, wind and solar power sectors. First, subsidies for fossil fuel usage in electricity generation increased substantially in the transition from the Lula to the Dilma administration (OECD 2019). However, their impact is largely limited

to off-grid power sources. Subsidies under the Fuel Consumption Fund, accounting for 70-85% of total fossil fuel subsidies in electricity generation, increased from US$1 billion to US$3.2 billion between 2007 and 2011, only to decline afterwards (ibid.). As this fund exclusively supports off-grid diesel power generation, it is not inconsistent with support for on-grid renewables, including those developed under the auction system, where feasible grid access is an eligibility criterion for participation. However, subsidy reductions reduce tensions for off-grid solar power, which has been expanding in recent years.[i]

Brazil's complex environmental licensing regime is a second source of policy incoherence affecting hydro and wind power expansion. Project developers must obtain multiple licenses under separate administrative procedures. Licensing processes suffer from inadequate planning, legal uncertainties and low-quality Environmental Impact Assessments, along with their insufficient review by regulatory authorities (World Bank 2008). The inability of hydropower developers to obtain licenses has, at times, led to the exclusion of hydropower projects from the auction system and their substitution with diesel power and natural gas (ibid: 16). In wind power, the licensing process similarly requires "great commitment in capital and managerial effort" (MEA 2014: 27). Public participation in licensing processes furthermore provides entry points for "blocking coalitions" that may attempt to strike down large infrastructure projects for reasons ranging from concerns over socio-environmental impacts to opposition on ideological grounds (Hochstetler 2011).

Third, access to preferential credit lines from the Brazilian National Development Bank (BNDES) for wind and solar power projects is tied to local content requirements that have been ratcheted up over time (Hochstetler and Kostka 2015). Brazil's comparatively high interest rates and the exchange rate risks that foreign lenders face imply that only limited financing options are available other than through the BNDES. For wind power, content requirements caused initial bottlenecks, yet, over time, incentivized global players such as the German manufacturer Siemens or the Danish manufacturer Vestas to build up

production capacities for wind power equipment in Brazil itself (MEA 2014). For solar, the lack of an adequate domestic manufacturing base for PV modules means that project developers continue to face challenges in complying with local content requirements.

Besides these sources of incoherence, synergy effects exist for the burgeoning solar microgeneration sector. ANEEL's Normative Resolution 482 of 2012 introduced net-metering for distributed generation systems, which is considered "an important mechanism fostering the dissemination of small PV solar systems" (Rocha et al. 2017: 1449). In 2015, distributed generation was granted exemption from the PIS and COFINS taxes, and states were given the option of eliminating ICMS taxation for electricity consumption up to the amount of electricity supplied under the net-metering scheme.[ii] The combination of net-metering and the ICMS tax exemption is highly effective in promoting the growth of solar microgeneration (ibid.).

3. Biofuels

Brazilian ethanol was first produced in the early 20th century and became a key feature of the domestic energy system during the 1970s. Ever since, the fuel has been available either as pure (hydrous) ethanol or as a gasoline blend, with pure gasoline not being sold on the domestic market. The sector was deregulated during the 1990s, first during the administration of Fernando Collor de Mello (1990-1992) and continuing under Cardoso (Ackrill and Kay 2014). Biodiesel only began playing a larger role under the Lula administration, which partially considered the upscaling of domestic production as a vehicle for social and regional development (Stattman et al. 2013). Complex linkages between the markets for oil and agricultural commodities influence the performance of the Brazilian biofuels sector. Producers enjoy some leeway in allocating sugarcane inputs between sugar milling and ethanol refining. World market

prices for sugar thus indirectly influence the amount of the sugarcane harvest committed to ethanol production. While anhydrous ethanol does not compete with gasoline due to mandatory blending, changes in gasoline prices influence the competitiveness of hydrous ethanol for users of the ubiquitous flex-fuel vehicles capable of running on any gasoline-ethanol blend (Nuñez and Önal 2016). While no competing fuel types exist for biodiesel blends, prices are shaped by developments on agricultural commodity markets, in particular soybeans as the primary feedstock used in Brazilian biodiesel refining (Stattman et al. 2013).

3.1 Instrument design

The primary policy instrument controlling the consumption of both anhydrous ethanol and biodiesel consists of mandatory blending mandates. Predictability is generally higher for ethanol than for biodiesel. The ethanol mandate fluctuates between 20 and 27% and is frequently subject to short-term adjustments to compensate for gaps between supply and demand (Barros 2016). Conversely, the biodiesel mandate has constantly been ramped up from an initial blend rate of 2% in 2008 to 10% in 2018, being aimed at predictable market expansion.

Brazilian governments tend to apply fiscal policy instruments in an *ad hoc* fashion, with various tax exemptions applying at different times and in different ways. Biofuels producers are generally exempt from the PIS and COFINS taxes. For ethanol, tax exemptions have been amended, introduced and removed in a more erratic fashion. Preferential taxation under CIDE[iii] was removed in 2012 and reintroduced in 2015. A 2013 exemption under the PIS/COFINS tax, intended to strengthen the sector's competitiveness, was discontinued by the Temer government in 2017. Since 2015, ethanol exports are eligible for tax credits amounting to 3% of total export value. The Dilma administration introduced additional *ad*

hoc and time-limited support measures to promote innovation in ethanol production, in the form of the 2011 Joint Plan for Industrial and Agricultural Innovation in the Sugar-based Energy and Chemical Sectors, and the 2012-2013 PRORENOVA initiative for supporting the renovation and expansion of sugarcane plantations.

The Temer administration chose a more comprehensive regulatory approach with the 2017 RenovaBio policy. Similar to the US Renewable Fuel Standard 2 or the Californian Low-Carbon Fuel Standard, the instrument creates a compliance market for biofuels. Fuel distributors must demonstrate compliance with their individual decarbonization targets through tradeable certificates that correspond to the GHG emissions avoided over the life cycle of a given type of biofuel. The instrument thus incentivizes shifts towards biofuels with lower carbon intensity, with decarbonization targets being set 10 years in advance delivering high levels of regulatory predictability (Denny 2020).

Biofuels figure as a critical component of long-term energy system planning. The 2007 Plan for Energy Expansion projects a more than threefold increase in domestic ethanol production by 2030. The production of biodiesel (as well as H-bio from hydrogenated mineral and vegetable oils) is expected to increase more than fivefold over the same time frame, reaching 487,000 barrels per day by 2030 (ibid: 42). According to the Brazilian NDC, biofuels are to constitute 18% of the national energy mix by the same year. Thus, in general, we are witnessing a trend towards greater instrument stringency, particularly in the context of RenovaBio. However, stringency tends to be greater for the case of biodiesel than it is for ethanol.

3.2 Coherence

Unlike for electricity, subsidies for fossil fuels in the transport sector constituted a major source of policy incoherence until at least the second half of the Dilma administration. Subsidies in the form of tax exemptions and reductions saw a strong increase beginning with the last year of the Lula administration and peaking at US$ 27 billion in 2013. Those measures are intended to "protect the domestic fuel consumers and reduce the inflationary effect of high fuel prices on other sectors of the economy" (Nuñez and Önal 2016: 320). However, preferential treatment under the PIS/COFINS and CIDE taxes, the largest contributors to overall transportation fossil fuel subsidies, saw significant reductions from 2014 to 2015. As the majority shareholder of the national oil company Petrobras, the Brazilian government has also periodically introduced gasoline price controls, including in response to the oil price hikes of 2007-2008, and again in 2012 (Fattouh et al. 2015).

All else being equal, such support measures drive up the demand for anhydrous ethanol to achieve compliance with the blending obligation, with readjustments to the blending ratio being able to reduce the resulting disparities between supply and demand. However, this simultaneously incentivizes the increased consumption of gasoline-ethanol blends relative to pure ethanol, due to their substitutability in the growing Brazilian flex-fuel vehicle fleet.

4. Conclusions

Our overall assessment presents somewhat of a mixed bag. We do not find an overall trend, either upwards or downwards, in instrument stringency, predictability or coherence. In the electricity sector, declining stringency in hydropower is met with greater ambition regarding wind and solar. Yet the low degree of predictability in renewable electricity auctions, as the primary policy instrument for stimulating market growth, creates uncertainty for economic operators. Reductions in fossil fuel subsidies improved

coherence after 2014. Important synergy effects exist in regards to distributed solar systems. Yet the complex licensing regime continues to impede hydro and wind power expansion. In the fuel sector, we witness a high degree of stringency as well as predictability for biodiesel. For ethanol, the blending mandate has increased over time yet is frequently subject to short-term re-adjustments. For both, the RenovaBio programme will potentially enhance both stringency and predictability. Here as well, declining fossil fuel subsidies after 2014 have improved coherence, although *ad hoc* changes to fiscal instruments as well as the use of price controls are a source of continuous tension.

Overall, Brazilian renewable energy policy is driven less by a mitigation rationale and more by short-term responses to unforeseen social and economic challenges. Declining stringency in hydropower policy at least partially results from opposition to the impacts of dam construction projects commonly implemented without sufficient social and environmental safeguards. Decreasing fossil fuel subsidies are mainly due to the introduction of fiscal austerity measures under the Temer administration. Price controls and tax rate changes in the fuel sector result from attempts at placating consumers and potential voters. The overall effectiveness of the renewable energy policy framework thus at least partially hinges on factors that are unrelated to emissions control. We thus agree with Vieira and Dalgaard (2013) in that Brazil's achievements in emissions mitigation are primarily unintentional by-products of policies intended for other purposes, while a discernible long-term strategy for decarbonization and environmental sustainability is sorely lacking.

Moving ahead, one key policy issue is the extent to which the expansion of solar and wind power can compensate for the relative decline in hydroelectricity and thus slow down or reverse the growth trend in natural gas consumption. In transportation, the primary challenge consists in ensuring the consistent expansion of biofuels production, while at the same time incentivizing greater consumption of hydrous over anhydrous ethanol. Insufficient commitment to mitigating energy-related GHG emissions, together

with inadequate control of emissions from land-use change and deforestation, also threatens to undermine Brazil's stature in international climate diplomacy, where temporary successes in curbing deforestation as well as the adoption of an absolute, economy-wide reduction target under the Paris Agreement lent credence to its claim of green leadership among the countries of the global South. Internationally, the administration's recent disengagement with multilateral climate diplomacy - for instance, its withdrawal from hosting the 25th Conference of the Parties to the UN Framework Convention on Climate Change or its intransigence regarding the operationalization of international carbon markets under the Paris Agreement - is unlikely to improve this overall situation.

Whether or not the Bolsonaro administration will have a substantial effect on Brazilian climate and energy policy cannot readily be ascertained at this stage. While its overall economic approach suggests a preference for market-based, deregulatory policies, those are chiefly rhetorical at present. The proposed privatization of Eletrobras, the largest electric utility in South America of which the Brazilian government is a majority shareholder, appears unlikely to garner sufficient votes in the Federal Senate. The prospects for the administration’s recent proposal to eliminate federal taxes on gasoline and petrodiesel are unclear. The same applies for a recent proposal that would facilitate oil and natural gas extraction on indigenous lands. A legislative proposal that would have granted tax exemptions for the import of solar equipment, however, was recently met with a presidential veto. Overall, the Bolsonaro presidency adds a degree of uncertainty to an already volatile policy environment, although the complexities of coalition politics in Brazil’s National Congress, as well as ideological divisions within the administration itself, limit the extent to which we should expect significant status quo deviations in the coming years. This, however, also implies that a substantial scaling-up of ambition, improved policy predictability and higher degrees of climate policy integration are extremely implausible in the near future.

References

Ackrill, R., & Kay, A. (2014) *The Growth of Biofuels in the 21st Century. Policy Drivers and Market Challenges*. New York: Palgrave.

ANEEL (2019) Editais de Geração, www.aneel.gov.br/geracao4 . Agência Nacional de Energia Elétrica.

Aquila, G., de Oliveira Pamplona, E., de Queiroz, A. R., Junior, P. R., & Fonseca, M. N. (2017). An Overview of Incentive Policies for the Expansion of Renewable Energy Generation in Electricity Power Systems and the Brazilian Experience. *Renewable and Sustainable Energy Reviews* 70: 1090-1098.

Azuela, G.E., Barroso, L., Khanna, A., Wang, X., Wu, Y., & Cunha, G. (2014) *Performance of Renewable Energy Auctions. Experience in Brazil, China and India*. Washington D.C.: World Bank.

Basso, L. (2019) Brazilian Energy-related Climate (In)Action and the Challenge of Deep Decarbonization. *Revista Brasileira de Política Internacional* 62(2): 1-21.

Carley, S., & Miller, C.J. (2012) Regulatory Stringency and Policy Drivers: A Reassessment of Renewable Portfolio Standards. *Policy Studies Journal* 40(4): 730-756.

Denny, D. M. T. (2020). Competitive Renewables as the Key to Energy Transition—RenovaBio: The Brazilian Biofuel Regulation. In: L. N. Guimarães (ed.), *The Regulation and Policy of Latin American Energy Transitions*. Elsevier, pp. 223-242.

Diógenes, J. R. F., Claro, J., & Rodrigues, J. C. (2019) Barriers to Onshore Wind Farm Implementation in Brazil. *Energy Policy* 128: 253-266.

Dutra, R. M., & Szklo, A. S. (2008). Incentive Policies for Promoting Wind Power Production in Brazil: Scenarios for the Alternative Energy Sources Incentive Program (PROINFA) under the New Brazilian Electric Power Sector Regulation. *Renewable Energy* 33(1): 65-76.

EPE (2019) Balanço Energético Nacional. www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/balanco-energetico-nacional-ben. *Empresa de Pesquisa Energética*.

Fattouh, B., de Oliveira, C. S., & Sen, A. (2015). *Gasoline and Diesel Pricing Reform in the BRIC Countries: A Comparison of Policy and Outcome*. Oxford Institute for Energy Studies, paper WPM 57.

IRENA (2019) *Renewable Capacity Statistics 2019*. International Renewable Energy Agency.

Jordan, A., & Lenschow, A. (2010) Environmental Policy Integration: A State of the Art Review. *Environmental Policy and Governance* 20(3), 147-158.

Kemp, R., Schot, J., & Hoogma, R. (1998) Regime Shifts to Sustainability through Processes of Niche Formation: The Approach of Strategic Niche Management. *Technology Analysis & Strategic Management* 10(2), 175-198.

Kemp, R., & Pontoglio, S. (2011) The Innovation Effects of Environmental Policy Instruments – A Typical Case of the Blind Men and the Elephant? *Ecological Economics* 72, 28-36.

La Rovere, E. L., Dubeux, C. B., Pereira, A. O., & Wills, W. (2013) Brazil beyond 2020: From Deforestation to the Energy Challenge. *Climate Policy* 13(1), 70-86.

Leite, A.D. (2009) *Energy in Brazil. Towards a Renewable Energy Dominated System*. London: Earthscan.

Losekann, L., Marrero, G. A., Ramos-Real, F. J., & de Almeida, E. L. F. (2013). Efficient Power Generating Portfolio in Brazil: Conciliating Cost, Emissions and Risk. *Energy Policy* 62: 301-314.

Markard, J., Raven, R., & Truffer, B. (2012) Sustainability Transitions: An Emerging Field of Research and its Prospects. *Research Policy* 41(6), 955-967.

Nilsson, M., Zamparutti, T., Petersen, J. E., Nykvist, B., Rudberg, P., & McGuinn, J. (2012) Understanding Policy Coherence: Analytical Framework and Examples of Sector-Environment Policy Interactions in the EU. *Environmental Policy and Governance* 22, 395-423.

Nuñez, H. M., & Önal, H. (2016) An Economic Analysis of Transportation Fuel Policies in Brazil: Fuel Choice, Land Use and Environmental Impacts. *Energy Economics* 55: 319-331.

OECD (2019) Inventory of Support Measures for Fossil Fuels. https://stats.oecd.org/Index.aspx?DataSetCode=FFS_BRA. Organization for Economic Co-operation and Development.

Rocha, L. C. S., Aquila, G., de Oliveira Pamplona, E., de Paiva, A. P., Chieregatti, B. G., & Lima, J. D. S. B. (2017). Photovoltaic Electricity Production in Brazil: A Stochastic Economic Viability Analysis for Small Systems in the Face of Net Metering and Tax Incentives. *Journal of Cleaner Production* 168: 1448-1462.

Rochedo, P. R. R., Soares-Filho, B., Schaeffer, R., Viola, E., Szklo, A., Lucena, A. F. P., Koberle, A., Davis, J. L., Rajão, R., & Rathmann, R. (2018) The Threat of Political Bargaining to Climate Mitigation in Brazil. *Nature Climate Change* 8(8): 695-698.

SEEG (2019) Sistema de Estimativas de Emissões e Remoções de Gases de Efeito Estufa, http://plataforma.seeg.eco.br/

Skeete, J.-P. (2017) Examining the Role of Policy Design and Policy Interaction in EU Automotive Emissions Performance Gaps. *Energy Policy* 104: 373-381.

Stattman, S. L., Hospes, O., & Mol, A. P. J. (2013) Governing Biofuels in Brazil: A Comparison of Ethanol and Biodiesel Policies. *Energy Policy* 61: 22-30.

Vieira, M. A., & Dalgaard, K. G. (2013) The Energy-Security-Climate Change Nexus in Brazil. *Environmental Politics* 22(4): 610-626.

Viola, E., & Basso, L. (2015) Brazilian Energy-Climate Policy and Politics towards Low Carbon Development. *Global Society* 29(3): 427-446.

---

[i] Those subsidy reductions may, however, cause some negative effects for small-scale ethanol producers relying on off-grid diesel generators.

[ii] PIS (*Programa de Integração Social*) and COFINS (*Contribuição para o Financiamento da Seguridade Social*) are value-added taxes at federal level; ICMS (*Imposto sobre Circulação de Mercadorias e Serviços*) is a value-added tax at state level.

[iii] CIDE (*Contribuição sobre Intervenção do Domínio Econônomico*) is a tax levied on certain services and products, including fuels.