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Brazil, Big Hydro, and a Beautiful Monster: “Green” Energy Generation in the Xingu River Basin

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Abstract

Brazil is quickly becoming an influential actor on the world stage of geopolitics. The nation has achieved global economic and environmental recognition due to the extensive development of its hydrological resources in the form of hydroelectric power plants. As the world’s second greatest generator of hydroelectricity, Brazil has proven a staunch adherence to building dams in the large-scale. Though these dams have brought electricity to millions of people across the country, the socio-ecological toll inflicted by their construction has been devastating to natural biomes and local inhabitants. This article traces Brazil’s proclivity for large-scale hydropower to four motivational categories often invoked to justify their construction to local, national, and global audiences. It finds that large dams in Brazil are framed as being politically necessary, economically practical, technologically innovative, and environmentally clean. The analysis grounds these framings in a case study of the recently completed Belo Monte Hydroelectric Complex on the Xingu River in the Northern Amazonian state of Pará. Situated in a biotically sensitive region home to numerous Indigenous communities and endemic flora and fauna, the dam is regarded as one of the most controversial infrastructure projects in the Amazon basin. Drawing from relevant historical context, the Belo Monte dam has benefitted from various tropes employed from the four motivational categories in the face of intense local and international opposition. With a national identity closely tied to hydropower, Brazil has demonstrated a continual reliance on large-scale hydroelectricity even when its future developmental potential in the country is questionable.

Keywords

Belo Monte, Brazil, developmental impacts, discursive framings, hydropower, hydroelectric dams, sustainability

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LIST OF ABBREVIATIONS

ANEEL	Brazilian National Electric Energy Agency (Portuguese)
EIA	U.S. Energy Information Agency
EPE	Energy Research Company (Portuguese)
GW	Gigawatt (1 GW = 1,000 MW)
IEA	International Energy Agency
IHA	International Hydropower Association
kWh	kilowatt hour
MW	Megawatt (1 MW = 1,000 kWh)
NESA	Norte Energia S.A.
PDE	10-year Energy Expansion Plan (Portuguese)
PNE	National Energy Plan (Portuguese)
toe	tonnes of oil equivalent (1 toe ≈ 11.63 MW)

{I} INTRODUCTION: BRAZILIAN HYDRO IN CONTEXT

Brazil is a notoriously conspicuous consumer and producer of hydropower. In 2019, Brazil had reported a total installed hydroelectric capacity of more than 109 Gigawatts (GW), the largest amount in South America, just ahead of the U.S. (102.75 GW) and second overall in the world behind only China (356.40 GW) (IHA 2020). Brazil also has the 3rd largest electrical grid in the western hemisphere, behind the U.S. and Canada. Most recent statistics show that hydropower contributed just under 65% to Brazil's domestic electricity generation matrix in 2019 (EPE 2020a), a downward trend from a decade-high amount of more than 80% in 2011 (EIA 2019). Owing to the country's extensive water resources, hydropower has been the traditional and trusted source of electricity in Brazil for decades. As estimated by the state-owned Energy Research Company (EPE in the Portuguese acronym), Brazil has a potential hydroelectric capacity of 172 GW, with an approximate 70% of the undeveloped potential located in the hydrologically sensitive Amazon and Tocantins-Araguaia basins in the west and center of the country respectively (EPE n.d.).[1] Though Brazil expects to increase its non-hydro renewables network mainly of solar, wind, and biomass up to 28% by 2027 (EPE 2017; EIA 2019), and take steps to gradually decentralize its energy generation (IHA 2020), it is still a country predominately reliant on hydropower.

In harnessing the flow of its rivers with hydroelectric plants, particularly those located within the Amazon basin, Brazil has displayed a tendency towards the large-scale. According to the Brazilian Electric Energy Agency (ANEEL), as of January 2019, there were a total of 217 large dams that have been constructed and are currently in active operation country wide (ANEEL 2019). With the completion of Belo Monte in 2019, Brazil now has 3 of the 10 largest dams in the world. For the purposes of this paper, Brazil defines large hydroelectric dams as any plant with an installed generating capacity greater than 30 Megawatts (MW) and a reservoir surface area greater than 3 km^2.[2] This definition however, does not do justice to

[1] The EPE cites Brazil's installed capacity as being more than 150 GW, with even more dam development by mid-century pushing that number close to 200 GW. As a note, some statistics presented in this paper are mostly based on data approximations. Discrepancies concerning hydropower generation statistics can fluctuate due to sources consulted for data reporting or certain plants intermittently going offline at different points in time.

[2] There is no international standard with which to compare the scale of dams since each country defines them differently. Since 2004, ANEEL has classified hydroelectric dams in two categories:

the scale of Brazilian hydropower. As recorded by ANEEL (2019), the nation boasts 26 dams that have between 1,000-5,000 MW of installed capacity, with the 3 largest dams in the country, Tucuruí and Belo Monte, located in the state of Pará, and Itaipu, saddling the Brazilian-Paraguay border, each capable of generating between 8,000 and 14,000 MW.

The Belo Monte dam on the Xingu River during the final stages of construction in 2015, Altamira, Brazil. Image source: Dextra Group do Brasil (www.dextragroup.com)

Future projections show that the Brazilian government has several plans in motion to add even more large-scale hydropower plants on the map. As one study has indicated, in the Amazon basin alone, between 2013 and 2028, 26 large-scale plants are slated to be built with a collective installed capacity of 44 GW, a reservoir area of 9,000 km^2, and a total cost ranging from $USD 30-70 billion (de Faria and Jaramillo 2017). The blistering pace and limitless approach to Brazil's hydroelectric development has not been without its obstacles. Many of these projects have raised serious questions regarding their long-term economic viability (e.g. Fearnside 2006; Higgins 2020), environmental cohesiveness (e.g. Millikan 2014; Fearnside 2016; Jiang *et al.* 2018), energy efficiency (e.g. de Faria and Jaramillo 2017; Higgins 2020), impacts to local health (e.g. Tallman *et al.* 2020), and mistreatment of the rights of Indigenous

conventional dams: >30 MW with a reservoir area >3 km^2; and small hydroelectric dams: 1-30 MW with a reservoir area $\leq$3 km^2 (cf. von Sperling 2012, 111).

communities and other affected groups (e.g. Jaichand and Sampaio 2013; Bratman 2014). These issues have manifested repeatedly, and sometimes violently, against many of Brazil's dam-building proposals. In the Xingu River basin, in the Northern Amazonian state of Pará, such troubles have materialized against the construction of the immense – and now fully operational – Belo Monte Hydroelectric Dam complex.

Considering the current and future state of hydroelectric development in Brazil, this paper seeks to investigate the South American nation's propensity for large-scale hydropower. It will consider the various methods in which large-scale hydro projects are precipitously built, frequently with rushed environmental impact assessments, poor planning, and cursory consultation of affected groups. This consideration will be based on an analysis of 4 broad categories that have been identified in framing the positive elements of mega dam construction in Brazil: political need, economic benefit, technological achievement, and environmental sustainability. Following the work of recent scholarship in this arena (Atkins 2017, 2018, 2019; Bratman 2014), it will be shown that large dams in Brazil are built according to various assertions employed from the 4 categories: Namely, that large dams are politically necessary, economically practical, technologically innovative, and provide environmentally 'clean' energy. After outlining the dynamics of the categories in more detail, the analysis will then center the application of these framings on the Belo Monte complex.

{II} BRAZIL'S HUNGER FOR WATER

Development of large-scale hydroelectric projects first came to the forefront of Brazil's energy policies during the 1970s, while the country was still under a military dictatorship (1964-1985). With concern building over Brazil's heavy reliance on imported energy and the intrusion of foreign energy companies, the military government decided to put plans in motion to further develop the country's domestic energy stocks. These plans called for the nationalization of existing energy and infrastructure companies, including those in hydropower, which sought to assert Brazil's energy independence and promote its extensive hydrological resources (Duran 2015). Some of the largest dams in the country now, such as Itaipu, Tucuruí, Samuel, Balbina, and even Belo Monte (then named Kararaô) were first envisioned by the regime. Under the military's directives from far away Brasilia, the Amazon biome became a prime target for hydroelectric development. Consequently, the region was rapidly transformed into a construction hub for dam building and other major connecting infrastructure, such as highways and canals. Never were any public consultation processes, environmental impact studies, or economic viability assessments carried out in monetary terms beforehand; the projects were always proposed without question or objection and built immediately, which has been the discernible trend in Brazilian infrastructure development since the dictatorship (Fearnside 2009). As it turns out, such endeavors undertaken by the military government at that time were part of broader aspirations "that sought to enroll the Amazon region into national efforts towards modernization" (Atkins 2018, 278) — a policy ethos that has even carried forward into Brazil's current administration (Speetjens 2020).

For Brazil, hydropower has been the main supply source of energy needed to meet the growing domestic demand for electricity, especially in the rapidly industrializing cities of the southeast. Total energy demand in the country has grown by almost 150% since 1990, reaching over 538-terawatt hours (TWh) in 2019 (IEA 2020). Corporate projections place Brazil's future primary energy demands to increase by 6% between 2018 and 2050, with per-capita energy consumption expected to rise by around 50% (British Petroleum 2020). Over this timeframe, the corporate outlook identifies the industry and transport sectors as the main drivers for this heightened demand, with the sectors set to expand by 83% and 59% respectively in a business-as-usual scenario (British Petroleum 2020). According to the Brazilian Energy Balance report — a yearly publication commissioned by the Energy Research Company to document Brazil's use and consumption of energy — in 2019, "industrial production and cargo/passenger transport account[ed] for approximately 63% of the country's energy consumption" (EPE 2020a, 25). As the report illuminates, in the industrial sector, production of paper and pulp materials represented the most energy intensive category by far, with processing of metals narrowly surpassing that of non-metallics for second-most intensive.[3] Meanwhile, in the transport sector, about 88% of energy

[3] Paper and pulp segments resulted in an energy intensity calculation of over 1,100 tonnes of oil equivalent (toe), which equates to approximately 12,793 million kilowatt hours (kWh). Metallurgy (such as pig iron, steel, ferroalloys, non-ferrous metals, etc.) and non-metallics (such as cement and ceramics) each had a result around 700 toe (~ 8.14 million kWh) in the energy intensity index (EPE 2020a, 29). This is significant as Brazil is one of the world's top exporters of paper and pulp products and has developed a significant market for mineral metals as well.

consumption was directed to the production of ethanol, gasoline, and diesel fuel, with the latter combustible accounting for almost half of the energy consumption at 41%.

All this is to say that hydropower has been chiefly prevalent to securing the Brazilian energy reality, given its dominance in the current electricity matrix. But, to match the forecasted rises in energy demands with hydropower, many more dams will be needed. The current 10-year Energy Expansion Plan 2020-2029 (PDE 2029) shows that 9 more large-scale dams are anticipated to enter operation by the end of the decade, with 3 in Amazonia (EPE 2019). Even though the PDE 2029 shows exponential gains to photovoltaic power by 2029, certain sections of the report give cause for concern. They indicate that more Indigenous land and protected biodiversity areas could be opened to hydroelectric development depending on the outcome of current bills circulating through Brazil's National Congress (Fearnside 2020).

{III} POLITICAL FRAMINGS: LARGE HYDRO AS <u>NECESSARY</u>

Large-scale hydroelectric dams would not be as pervasive in Brazil as they already are if they were not seen as politically "necessary" to generate the energy the country needs. In addition to the PDE 2029, Brazil's EPE also released a "National Energy Plan" (PNE) outlining the country's long-term plans for the energy sector up to 2050. The report makes clear the impact that hydropower is expected to still have on the country's electrical energy matrix by then, with another 52 GW of energy from large-scale plants anticipated to be added to the country's current level of installed hydro-electric capacity, bring-ing it up to 154 GW. If small-scale hydropower (<30 MW installed capacity) is included into Brazil's overall potential hydropower energy mix, the grand total climbs to 176 GW by mid-century (EPE 2020), a yearly projected growth rate of 2.25%. This amount would easily pace the estimated world hydropower growth of 2% that would be needed to meet global climate change targets by 2050 (IHA 2020). For Brazil, to help achieve this goal will require many more hydropower plants to be constructed over the coming years, (see *Fig. 1*, pg. 6).

For ordinary Brazilians, hydropower is not viewed as just a way to provide for the country's overall energy needs, it is safety net that ensures consistent and reliable energy availability. Many "Brasileiros/as" can relate to a collective traumatic experience of widespread blackouts and energy rationing when prolonged periods of drought reduced hydropower production across the country in the early 2000s and again in 2013. As such, the

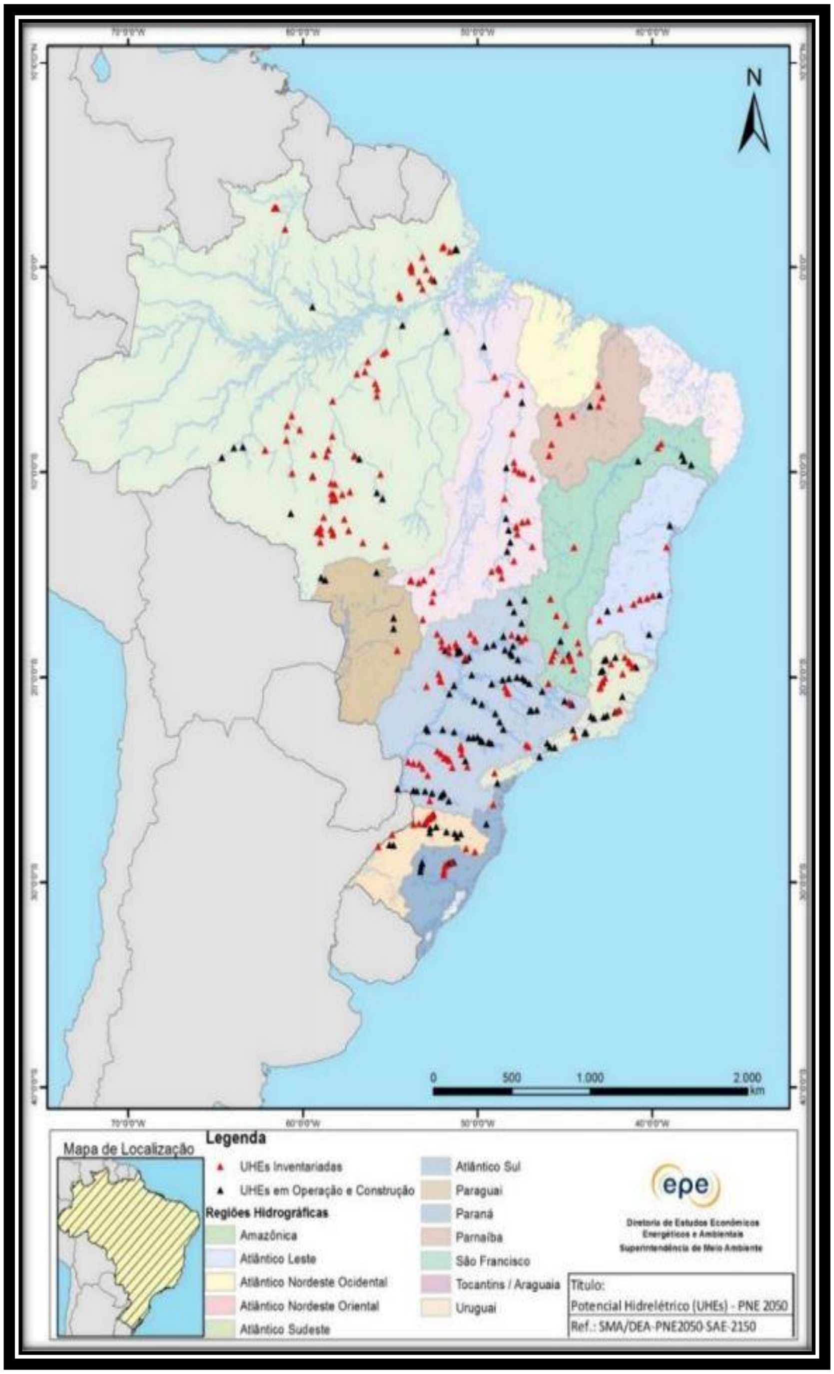

Fig 1, above: The long-term distribution of hydroelectric potential throughout Brazil up to 2050 by hydrographic region. Black triangles indicate the amount of large dams (>30 MW installed capacity) that have been completed or are under construction while red triangles signify dams that are under consideration for future construction. As indicated, Amazonia continues to garner substantial hydroelectric interest. Source: EPE 2020b, 77 (cf. Fearnside 2020).

country turned to large-scale energy generation projects, including large hydropower plants, as the solution to ensuring that it would never lack for energy again (Atkins 2017). In the heavily populated Southeast, the concern was not so much from where or by what means electricity was "delivered" to local distribution stations, so long as the lights or other household appliances could be turned on when needed. But as prominent biologist and scholar of dam-building in Amazonia, Dr. Phillip Fearnside, attests in an interview (cf. Lyons 2014), Brazil must first ascertain what constitutes a "need." As will be evident across the various framing categories, it is the recurring dynamic of "need" that has had a key role in shepherding so many large hydro plants across the finish line in Brazil, dodgy deals be darned.

Ed Atkins' scholarship has been particularly influential in assessing the political and environmental discourses of the pro-dam coalition in Brazil, especially in the context of the Belo Monte dam. In a series of recent works (Atkins 2017, 2018, 2019), he has demonstrated that the Brazilian government, along with other dam-building interests, employ similar discursive tactics to those of other nation states who engage in mega dam projects. Such tactics have sought to legitimize the construction of dams as a procedure of "nation building" or progressing towards "modernization of the state" (e.g Kaika 2006; Bridge *et al.* 2018). Specifically, Atkins notes the inherent linkages to hydroelectric development that the Brazilian state understands as a form of collective identity and source of national pride (Atkins 2017, 2018). As the preeminent "hydro state" in South America (and in the western hemisphere for good measure), Brazil understands that hydroelectricity is what has made it the burgeoning global actor it is today. As Atkins (2019) attests through his research, hydropower is inherently always in the "national interest" of Brazil, meaning the construction of large-scale dams, such as Belo Monte, is regarded as inevitable, both for the "good" of the social order and the national economy.

{IV} ECONOMIC FRAMINGS: LARGE HYDRO AS PRACTICAL

In Brazil, large-scale hydropower can provide many economic benefits. In addition to the increased employment posts offered during construction phases as well as opportunities for greater tax revenues in the surrounding regions, hydroelectricity plants provide a substantial basis for the country's economy to proceed. Hydroelectricity is particularly relied upon for the energy demands of processing agricultural and industrial commodities. These include valuable goods such as coffee, soybeans, beef, iron ore, sugarcane, and orange juice, which accounted for about 45% of all exports and a combined value of 26.7% to Brazil's GDP in most recent estimates (Pines 2020). Brazil is also a major world producer of paper and pulp products, which, as mentioned earlier, is the most energy intensive industry in the country.

From a cost-benefit perspective, large-scale hydroelectric plants in Brazil supposedly provide a win-win situation to all parties involved. Not only do they contribute a substantial amount to the country's energy differential, but large singular plants are proposed to generate more electricity than smaller, more numerous, solar and wind installations, of which Brazil has abundant reserves (de Faria et al. 2017; Lyons 2014; de Souza Dias et al. 2018). Generally, dams also can lead lengthy economic lives, some up to 100 years, and have low operating labor costs throughout that time given that most stations are automated (von Sperling 2012). However, maintenance costs — such as those involved in the upkeep of the electricity-generating turbines, which are usually the most expensive part of any large hydroelectric project — need to be factored into potential cost overruns throughout the life of the dam (Awojobi and Jenkins 2015).

To muster local support for their projects, dam companies in Brazil promise social and economic development incentives as a trade-off to impacted regions (Fearnside 2017). This offer can come in the form of providing connecting or ancillary infrastructure, such as roads, canals, or hospitals. The perceived public benefit of these opportunities can also work to divide resistance groups opposed to the dam in question (Bratman 2014). Moreover, financial compensation mechanisms provided to communities displaced by the flooding of dams could also be used to leverage local development; rather, evidence has shown financial compensation to have negative associations in relation to development, due in part to a lack of institutional enforcement guidelines at the national level (Pulice and Moretto 2017).

Numerous studies of the economic impacts from hydroelectric development in Brazil show that dam building can provide a significant economic boost, especially during the construction stages, but that this will eventually dissipate over time (Assunção, Szerman, and Costa 2017; de Faria *et al.* 2017). According to one study of Brazil's renewable energy potential, de Jong *et al.* (2015) calculated that wind power in Brazil, given the inclusion of a discount rate of 10% and certain external costs, becomes a cheaper energy source than the conventional hydroelectric dam. Though the Brazilian government is moving to increase its share of renewables in addition to hydropower, alternative energy generation continues to encounter political and economic barriers.

Such obstacles confronting Brazil's implementation of alternative energy sources became clear in the fallout of Operation Car Wash, or *Lava Jato*, in 2016. A sweeping anti-corruption probe connecting top government officials throughout the country and across the continent, *Lava Jato* uncovered a shadowy ring of major corporate construction leaders, bureaucrats, politicians, and even the Brazilian President at the time, with using some of the country's largest dam projects to illegally generate funds for political parties (Watts 2016).

The findings from the Operation place new meaning behind the economic framing of large dams in Brazil as "practical," given the slew of interests set to benefit from their construction.

{V} TECHNOLOGICAL FRAMINGS: LARGE HYDRO AS INNOVATIVE

While construction companies and politicians worked behind-the-scenes to negotiate kickbacks and other benefits for building large dams, when out in the public domain, they promoted them as technologically "innovative." In this case, such claims of innovation often incorporate various references to state-of-the-art advancements in hydroelectric components present within the dams or to improved designs that supposedly lessen their environmental impact. In Brazil, proponents also seek to distance the current generation of dams from the much more environmentally destructive and inefficient ones that came out of the military dictatorship (Fearnside 2009, 2017; Atkins 2017). This stance, however, does not deter critics from questioning the viability of dams presented in modern-day Brazil versus those proposed from nearly 4 decades ago. As Dr. Fearnside (2009, 1) establishes in a paper presented at an academic conference regarding development in the Amazon basin:

> "The currently unfolding history of major projects suggests that not much has changed [since the military dictatorship]. Major projects that would set in motion chains of events with enormous environmental and human consequences are still decided by a handful of high officials and are announced and treated as "irreversible" before any environmental or economic viability study is done."

Brazil's approach to dam building has indeed improved over the years due in part to the requirement of environmental impact studies, public hearings, community consultations, and technical assistance provided by the World Bank (see Rex *et al.* 2014). Amongst the broader population, hydroelectric development has taken on new significance with the widening recognition of the effects of climate change and the rights of Indigenous communities, thanks in part to the influence of NGO awareness campaigns (Bratman 2014). The rise of alternative energy generation sources in renewables such as wind, solar, tidal, geothermal, biomass, and many others, continues to pressure the international market away from traditional fossil fuel sources (Gielen *et al.* 2019). But amidst the rapidly improving technologies and declining costs in the alternative renewables sector, Brazil still maintains and defends its preference for large-scale hydroelectric dams. Such a staunch stance is not uncommon for Latin America, where historically, in conjunction with corrupt governments, large dams have been the preferred route to seize the economic benefits of rapid industrialization, urbanization, and electrification (see Vidal 2017).

In the process, innovations to hydraulic systems have brought new technologies for controlling critical water supplies, such as pumped storage hydropower, to the conventional dam fleets of both Brazil and Latin America. Also known as a "water battery", pumped storage hydropower can offset the variability of other renewable energy sources and provide increased system reliability. It also sets itself apart from other energy storage systems for "its long asset life, low lifetime cost, and independence from raw material availability" in addition to the ability to be retrofitted on existing conventional hydro stations (IHA 2020, 13). Brazil is currently exploring the possibility of adding pumped storage hydropower to its grid, identifying 15 locations last year in Rio de Janerio state with a total potential output of 21,109 MW (Hydro Review 2019).

{VI} ENVIRONMENTAL FRAMINGS: LARGE HYDRO AS "CLEAN" ENERGY

Regardless of size and scale, framings of hydroelectric dams as "sustainable" and provisioners of "clean energy" dominate the environmental discourse of hydropower in Brazil. Certain connotations of "renewable energy" abound as well.[4] According to Brazil's PNE 2050 energy plan, the Nationally Determined Contribution to the reduction of carbon emissions is to reduce greenhouse gas emissions 37% by 2025 and 43% by 2030 from 2005 levels (EPE 2020b, 35). Unfortunately, climate change is already beginning to have consequential impacts for hydroelectric dams in Brazil. In an analysis of previous studies of hydropower reservoirs in the country, de Souza Dias *et al.* (2018) note that, among other concerns, climatic variation directly affects the volume of water available for electricity generation and higher temperatures can cause evaporation from storage reservoirs. The

[4] Brazilian energy agencies equate "hydroelectricity" with "renewable" but make no distinction in terms of scale. Therefore, even though large-scale plants have much more of an impact on local ecosystems than small-scale plants, large-scale dams are equally justifiable in terms of creating "renewable energy." The International Renewable Energy Agency (IRENA) makes no explicit legal distinction either whether large hydropower should be considered "renewable" or not but does consider small-scale "hydropower without dams and reservoirs … a more environmentally friendly option" (see https://irena.org/hydropower).

authors also caution that Brazil will need to opt for a combined study of the hydrological and climatic variables that will inevitably affect future hydropower generation in the country, including consideration of wind and solar generation (de Souza Dias *et al.* 2018). This is wise advice for a nation so heavily reliant on hydroelectricity as Brazil, but by continuing to expand large hydroelectric development in the country, Brazil has made it clear that big hydro is very much a part of any future infrastructure development.

Furthermore, Brazil's hydroelectric dams in the Amazon basin have been proven to indirectly produce greenhouse gas emissions, including methane, which has a much greater warming potential than carbon dioxide (Fearnside 2016). Interestingly, new capture technologies are emerging that could be installed at dam sites to aid in the recovery of methane, thereby slightly diminishing the climatological impact of large dams (Lima *et al.* 2008). The Brazilian state also appears willing to be flexible with future large dam designs, exhibiting a conscious shift towards building dams with a run-of-the-river system that reduces the socio-ecological impact of storage reservoirs (Burrier 2016). However, since these dams rely on the natural flow of the river, they become more susceptible to the hydrological impacts of climate change, potentially leading to the erection of fossil fuel plants alongside the dams to make up energy differentials in low-flow periods (de Souza Dias *et al.* 2018).

{VII} FRAMINGS OF BELO MONTE

Located on a curve of the north-flowing Xingu River referred to as the *Volta Grande*, or the "Big Bend," the massive 90 meter-high, 11,233 MW Belo Monte dam came fully online in November of 2019 with the installment of the 18th and final turbine. In the process, it officially became the fourth largest dam in the world by installed capacity. Translated as "Beautiful Hill" from the Portuguese, it is regarded as one of the most controversial dams ever built in Brazil due to its wide-ranging socio-ecological impacts and association with corruption. As a result, the dam has been given a new name: "*Belo Monstro"* — "Beautiful Monster." As the previous section of the paper outlined 4 broad categories invoked in the building of large dams in Brazil, this section will now note their application to Belo Monte.

Political

First conceptualized in the mid-1970s, plans for building Belo Monte toggled on and off for decades until finally finding a home in the early 2000s within the administrations of Luiz Inácio da Silva (hereafter Lula) and his successor, Dilma Rousseff, both members of the *Partido dos Trabalhadores* (Worker's Party). In the face of a diverse and multi-actor coalition of protestors, Lula and Rousseff remained key proponents of the dam, promoting it as the figurehead of government-led programs seeking to develop and modernize infrastructure in the Amazon region and throughout the rest of the country (Atkins 2017, 2019). As international outcry over the dam's proposed impacts grew and blackouts across Brazil became longer and more frequent, Belo Monte became substantiated as a project of national identity and domestic political importance, with frequent citations as being 100% Brazilian (Atkins 2017; Fearnside 2017). Bratman (2014) also has noted that the international coalition of actors lined up against the dam helped to deepen nationalist sentiments of the dam as Brazil working to establish sovereignty over its Amazon region.

In addition to notions of regional sovereignty, Atkins (2017) has identified multiple instances of framings of Belo Monte as a project of national importance in an analysis of speeches given by Brazilian Deputies within the National Congress. Some Deputies refer to the grandeur of Belo Monte, noting "the importance that this plant will have in generating energy for our country" and as being "in favor of Brazilians." Deputies from opposing parties even put aside partisan differences in framing the dam as being an "apolitical" venture and "not a government project [but] a project of the Nation." Further quotes acknowledge the interference of external actors in holding up the dam, who "wish to derail our development, who want to stifle the Amazon, and not allow us to make the most of our hydroelectric potential …" Even Lula himself fought back against international outcry against the dam, asserting that "This is Brazil, *our* country … because we shall care for our forest and we shall take care of our development" (quotes cf. Atkins 2017, 283-5).

Economic

The projected cost of Belo Monte is substantial, initially pegged around BRL 40 billion in 2011 (roughly USD 9.5 billion), but this cost has surely grown in tandem with the rising socio-ecological costs of the dam (Higgins 2020). The dam had been heavily promoted by advocates as a panacea for local development and employment opportunities in the region and in Altamira, the nearest sizable town. A recent enlightening study by Calvi *et al.* (2020) does indeed show that employment increased in the municipality around the dam from around 10,000 jobs in 2011 to more than 43,000 in 2014 near the height of construction; however, by 2017 employment rates across all economic sectors had returned to pre-dam levels. The study also attempted to find supporting evidence for claims that Belo Monte would boost rural development in food production and create greater demand in the markets of Altamira. Instead, it found that many rural workers migrated to urban areas to search for jobs, leading to rises in wage costs and devastating the region's agricultural production. As a result, the researchers estimate around 60% of farmers gave up on annual crops such as rice, corn, and beans in favor of higher-value cocoa and cattle. The decrease in agricultural activity in the region has now also made Altamira reliant on food imports from other Brazilian states (Calvi *et al.* 2020).

Population in the city of Altamira also doubled during the time Belo Monte was being constructed, mainly due to housing workers from the dam site and from the surge of outsiders looking to cash in on new economic opportunities. As construction on the dam continued, the city also expanded its borders further into the rainforest, bringing new dwellings, shopping malls, business centers, and other commercial ventures onto increasingly valuable forested land (Faiola, Lopes, and Mooney 2019). The "price of progress" may have brought more people and an economic growth spurt into the city, but it has also brought a wave of urban chaos and violence. In 2015, Altamira had the unfortunate distinction of being named the most dangerous city in Brazil, with 107 violent deaths per 100,000 inhabitants in one year alone, 4 times above the national average at the time (MAB 2017).

Technological

Significant promise for Belo Monte was seen in the way it was designed as a run-of-the-river plant with a drastically reduced reservoir area (1,225 km^2 to 478 km^2) and efficient turbines that would supply, as one Brazilian Deputy claimed, "the cheapest kilowatt output in the world" (Atkins 2017, 287). Considering the praise heaped upon the dam for its stated efficiency and innovative techniques, so far, it has proved underwhelming. Even though Belo Monte has an installed capacity of 11,233 MW, its approximated monthly generating output is much lower at 4,571 MW, or about 41% of full declared output. This approximation is even further inflated due to the questionable siting of a dam this large on a river with seasonally variable flows. In 2019, Belo Monte underproduced energy for half the year, generating a monthly average around 647 MW from July through November, an amount far away from the numbers proclaimed by the dam's investors (Higgins 2020).

The technological innovations of Belo Monte make it stand out in the minds of proponents due to its marked differences from hydroelectric plants of the past, such as Balbina in the nearby state of Amazonas, that have contributed severe environmental impact through flooding of their reservoirs (Fearnside 2009). Norte Energia S.A. (NESA), the consortium responsible for building and operating Belo Monte also take pride in the engineering and technological achievements that made the dam possible. As listed on their website, Belo Monte exceeds the other largest hydroelectric plants in the world in terms of the sheer volume of land and rock moved during construction.[5] The plant is also considered by the group as one of the safest in all of Brazil, with access to a robust and stringent monitoring and evaluation system.[6]

Environmental

Claims of the sustainable nature of Belo Monte are one of the more common framings that have been attached to the dam. NESA has an entire web page dedicated to the sustainability initiatives surrounding the dam, noting their commitments to maintaining high levels of water quality, the protection of endemic flora and fauna, and the safe passage of native fish species through the dam's reservoir.[7] Other resources point to the environmental licensing process for the dam that has asserted NESA's commitment to sustainable development in the region through environmental monitoring and close engagement with impacted communities.[8] Limited environmental impact was a favorite string to pull for

[5] Retrieved from: <https://www.norteenergiasa.com.br/pt-br/uhe-belo-monte/arranjo>.

[6] Retrieved from: <https://www.norteenergiasa.com.br/pt-br/uhe-belo-monte/segurancabarragens>.

[7] Retrieved from: <https://www.norteenergiasa.com.br/pt-br/sustentabilidade/legados-ambientais>.

[8] Retrieved from: <https://www.norteenergiasa.com.br/pt-br/sustentabilidade/licenciamento-ambiental/processo>.

proponents of the dam. In one instance, at the pinnacle of opposition to the project, the Brazilian government produced a video that was played throughout the country's airports during the Rio+20 summit advertising the dam to have zero consequences for Indigenous communities living alongside the Big Bend of the Xingu River (Millikan 2014). Other environmental framings position Belo Monte as a deterrent against further investment in more polluting energy generation, such as nuclear, thermal, or fossil fuel plants, that would have to be built instead to keep pace with Brazil's energy demands (Atkins 2017, 2018).

{VIII} CONCLUSION

This paper sought to further understand the framing devices behind Brazil's general preference for large hydroelectric dams and their application to the Belo Monte dam complex. Overall, it was determined that large hydropower dams in Brazil are constructed according to various conceptualizations of political need, economic practicality, technological innovation, and environmental sustainability. Within political framings, large dams can serve as models of Brazilian national identity and energy sovereignty while generating the electricity needed for the country to avoid future blackouts. Definitions of what constitutes a need, however, should be pre-established. In economic framings, large dams provide the electricity required for the country's economy to succeed and can generate more energy than other, smaller, sources. The perceived long-term benefits of large dams for regional employment and economic activity, though, are contestable. Technological framings posit that large dams in Brazil today are much more efficient and less impactful due to advances in structural designs and external components. Observers question this rationale given the extensive socio-ecological impacts that large dams still have in Brazil. Environmental framings indicate that large dams in Brazil can help the country achieve targeted reductions in climate emissions and present an outward appearance as a predominantly renewables-based country. Hydroelectric dams in the country, however, have been shown to contribute greenhouse gas emissions and wide-reaching environmental degradation.

The Belo Monte dam has received a strong dose of each of the framings presented in this paper. In brief, it was constructed in (ultra) large scale to provide national energy security; generate economic development; stand as a model of innovative design; and as a method to continue utilizing Brazil's hydrological resources. As this paper has demonstrated, the framings behind large dams in Brazil are much more nuanced than they are publicly purported to be. Though Brazil is beginning to take steps away from large dams, they are still firmly entrenched in the country's future developmental agenda. As such, opportunities for further research into the dynamics and impacts of large dams will continue to be necessary.

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