Accomplishing the Nationally Determined Contributions in Brazil: the efforts of the Brazilian electrical sector in the implementation of the Paris Agreement

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ABSTRACT

Four years after the Paris Agreement on climate change, the Brazilian Government are still struggling with the first draft of the *National Strategy for the Implementation and Financing of Brazil's Nationally Determined Contributions (NDC).* Based on simulations demonstrating Brazil's ability to generate 100% of its electricity from renewable sources, the present study aims to analyze the status of Brazil's NDCs and establish a link with ongoing process reform of the electric legal framework. In the results, this study shows that the Brazilian electricity sector is not contributing to the achievement of the Paris targets, rather it has become more carbon intensive and an increase in greenhouse gas emissions is predicted for the next few decades. In favor a new paradigm for the sector is presented here, based on eco-efficiency, resilience, effective equality and sustainable socio-environmental development, with special attention to the Paris targets and Agenda 2030.

KEYWORDS

Renewable generation. Brazilian electricity grid. Brazilian legal framework. Nationally determined contributions. Paris Agreement.

INTRODUCTION

Present work analyses the efforts of the Brazilian electrical sector in the implementation of the Paris Agreement, from a technical and legal perspective. The study investigates real possibilities and impacts of the ongoing process of reform of the electricity markets and propose legal alternatives routes that may enable a better future for all. For this it part from the current prospect and the context of energy transition and climate crisis.

The final objective is present proposal of regulations that can enable a 100% renewable, economically just, safe and environmental friendly electricity matrix, helping the development of Brazil in the near future.

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METHODOLOGY

The method used in this work can be considered qualitative, applied, descriptive and exploratory.

Extensive bibliographical and documentary research was carried out. The primary data were taken from official sources, national and international reports and other public domain documents. The study started from the assumptions that: (*i*) national regulation is indispensable for meeting the Paris goals, (*ii*) the country's efforts must go beyond simple compliance of the Nationally Determined Contributions (NDCs), (*iii*) the Brazilian electricity legal framework has a structural contradiction that discourages gains in energy efficiency, privileges large consumers to the detriment of smaller ones and allocates resources in a non-optimal way, and finally, (*iv*) it is feasible to meet Brazil's electricity demand with 100% renewable generation.

First, a survey and revision of the state-of-art climate change politics and regulatory energy frameworks in world (and specially in the Brazilian context) was carried out. Then, analyses of the political and socioeconomic context of Brazil and of the impacts of the regulations in the development of the national electricity sector in the recent years were done. Finally, the formulation of hypotheses of changes in favour of regulatory evolution were elaborated.

The research, therefore, was divided into the following stages: *(i)* survey of literature with a view to the characterization and analysis of the current energy context, nationally and internationally; *(ii)* selection and evaluation of the so-called determining factors; *(iii)* construction of hypotheses that contemplate regulatory proposals to improve the Brazilian commitments to the UN Climate Change Framework. These hypotheses offer more coherent expansion of the national electricity grid through the leers of eco-efficiency, social equality, safety and resilience.

Based on simulations demonstrating Brazil's ability to generate 100% of its electricity from renewable sources found in the literature survey, the present study aims to analyze the current implementation process of Brazil's NDCs and establish a link with process reform of the legal framework of the electricity sector.

In the results, we present suggestions that should help to reach 100% renewable generation in the Brazilian electricity grid before 2050.

LITERATURE OVERVIEW

Humanity is facing an urgent existential crisis that threatens life on Earth as we are edging ever closer to a point of no return [1-3]. Preventing this catastrophe requires the efforts of the entire international community at all levels of government and civil society. If human kind wants to limit global warming to 1.5ºC and avoid worst consequences of the climate crisis, it has to immediately start an unprecedented effort to rapidly reduce greenhouse gas (GHG) emissions to net zero by 2050 [3,4].

The construction of a scenario that limits global warming well below 2ºC requires the immediate dissociation between electricity generation and GHG emissions, especially when it comes to expanding generation capacity [5]. The power plants that will be installed from now will be active for at least two decades. However, regardless of source, their emissions will accumulate in the atmosphere for the next century.

The global climate in 2030 is already defined by emissions produced until now [5], it remains to know what can be done for the future generations. Initiating mitigation and adaptation actions as soon as possible are imperative [3,6].

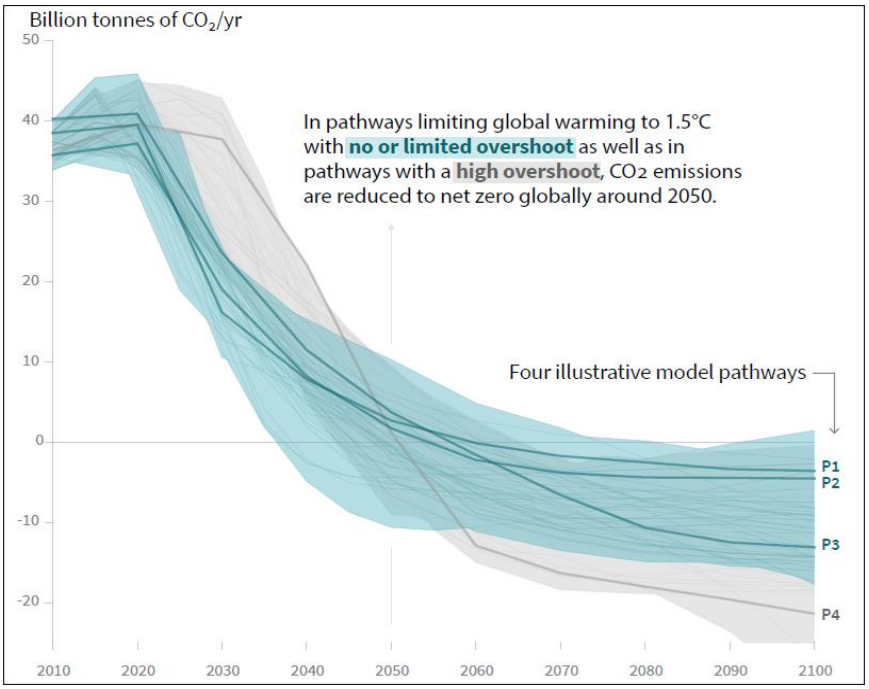

Figure 1. Global CO_2 emissions in pathways limiting global warming to 1.5°C, from [3]

The energy system (electricity, heat and cooling) is one of the main producers of GHG emissions, responsible for 49% of the total global emissions in 2014 [7]. Global energy-related CO_2 rose by 1.4% in 2017 and reached a historic high of 32.5 gigatonnes (Gt). The growth contrasts with the need to reduce to meet the goals of the Paris Agreement [3,7].

The pathway of 1.5ºC (<450ppm scenario), indicated in the figure above, requires profound changes in the global economy and in particular in electric energy production chains, in order to obtain practically all the electricity and heating/cooling required to meet human needs through non-fossil sources. Facing this challenge this is extremely important, especially when it comes to expanding installed capacity, building ways to produce the "new energy" [5].

From Synthesis Report of the Intergovernmental Panel on Climate Change [3,6] it is clear that:

> (...) we have the means to limit climate change and its risks, with many solutions that allow for continued economic and human development. However, stabilizing temperature increase to below 2°C relative to pre-industrial levels will require an urgent and fundamental departure from business as usual. Moreover, the longer we wait to take action, the more it will cost and the greater the technological, economic, social and institutional challenges we will face [6].

The distance between current polices, how much should be done to fully achieve the initial Paris targets (Pledges), and the effort required to maintain the average global temperature

increase between +1.5°C and +2°C can be visualized in Figure 2 below, which relates quantity of emissions in GtC02e per year, over time, with predictions for 2030.

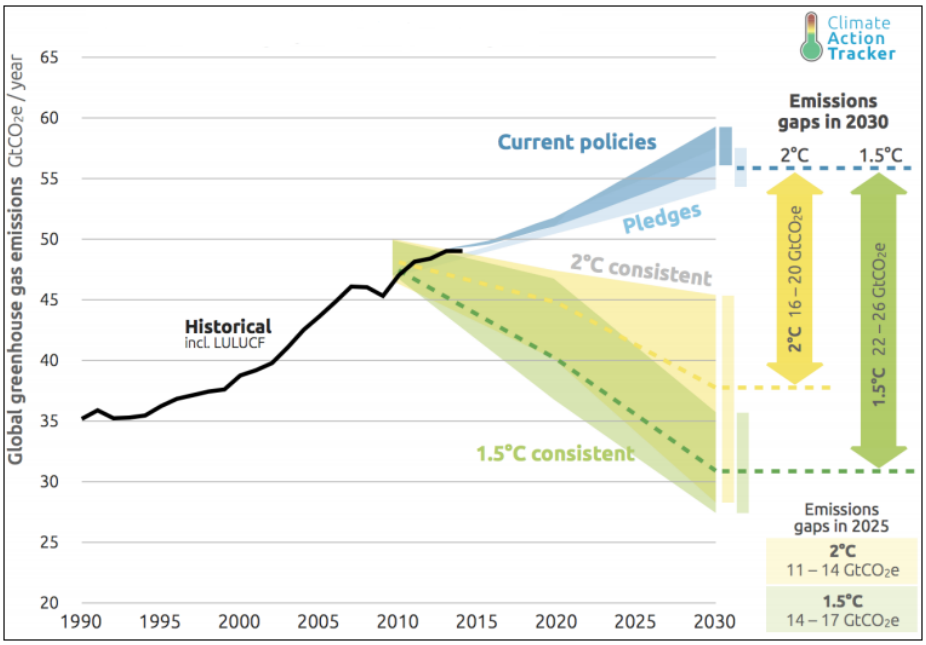

Figure 2. Climate Action Tracker – Emissions Gaps in 2030; From: [8]

According to the report, the difference between projected and real emissions already exceeds 5GtCO2e. In addition, with the current trend, it is estimated that the gap should reach between 12 and 14 GtCO2e in 2025, as can be seen in the on the right part [8].

The set of NDCs adopted for the period 2020 and 2030, therefore, do not represent a consistent trajectory with the goal of limiting climate change to a maximum of 2°C [3,8,9]. Aware of this, Cortekar & Groth [10] have already warned that actions to adapt to the impacts of climate change must gain more and more relevance due to the low probability of a reversal of the tendency to increase GHGs.

In the world scenario of climate change, Brazil is in a privileged position, since it has an electrical matrix with low GHGs emissions and also has great potential for renewable energy generation to be exploited, especially wind and solar [9, 11-15].

The challenges to accomplish Brazil's Nationally Determined Contributions

When the Paris Agreement was signed, joining efforts to adopt a low-carbon economy by the end of this century, Brazil committed to reducing GHGs emissions by 37% by 2025 and presented an indicative reduction target of 43% by 2030, both compared to 2005 levels [16].

The main challenges posed to the planning of the Brazilian's electricity sector by the NDCs are related to the expansion of installed capacity, guaranteeing affordable prices and greener energy to meet the future demand in a changing environment.

Despite the immense renewable generation potential, 440GWp just for onshore wind, with an excellent capacity factor, capable of producing an estimated 1,677 TWh/year [17], and 307GWp of solar just in areas already anthropized, with high levels of radiation (6000-6200

Wh/m²), with an estimated annual generation of 506 TWh/year [17], the electric matrix has been systematically increasing its emission intensity over time [18, 19], as shown in the graph (Fig.3) below.

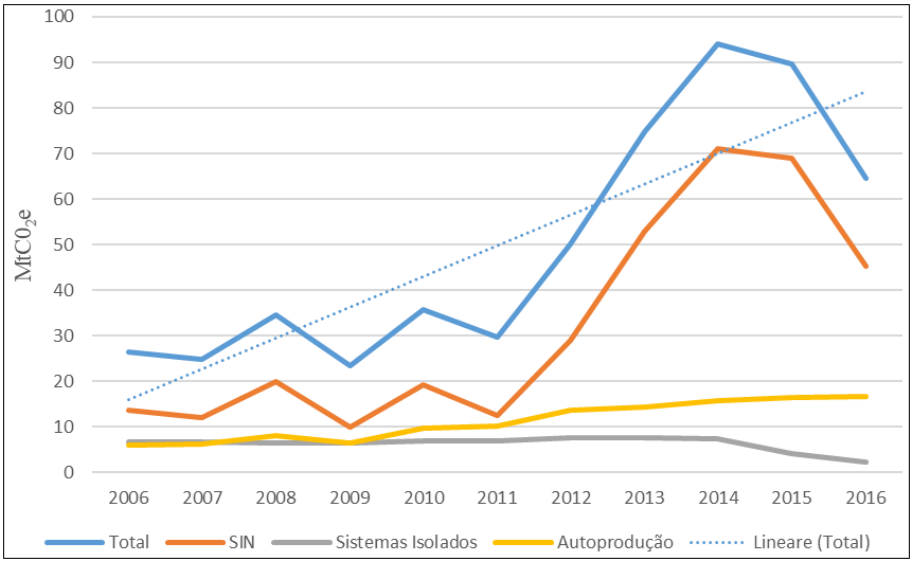

Figure 3. GHG Emissions in the Brazilian Electricity Matrix, 2006 – 2017. Data from: [19]

The comparison of Figures 4 and 5 [20] demonstrates how Brazil is going against the world trend and risks losing even more competition in a new global scenario that imposes a price on carbon or losses and damages for climatic events.

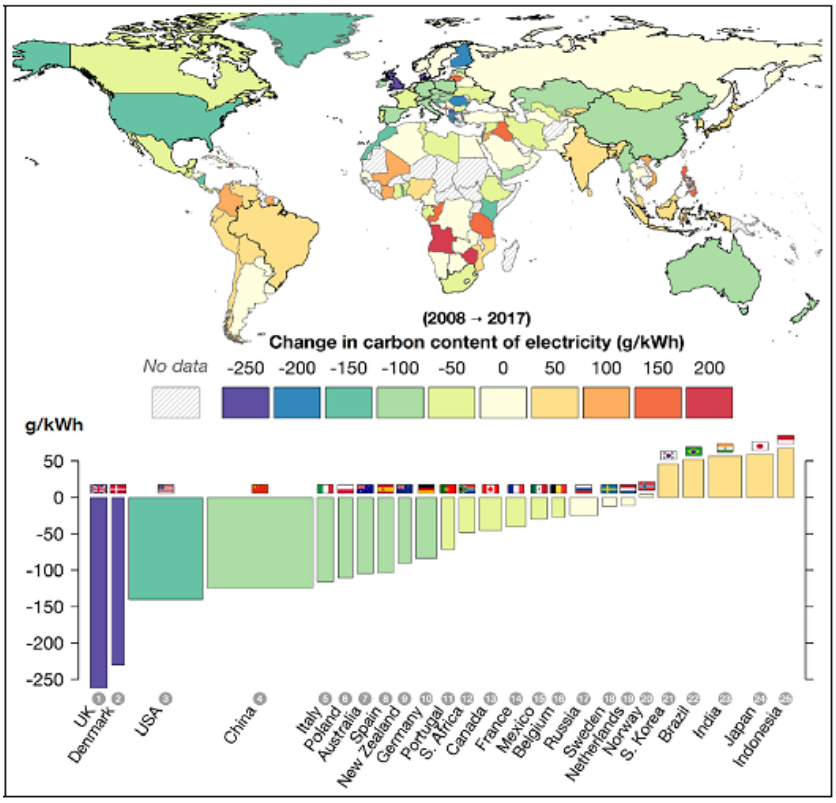

Figure 4. Change in carbon content of electricity (g/KWh) from 2008 to 2017.

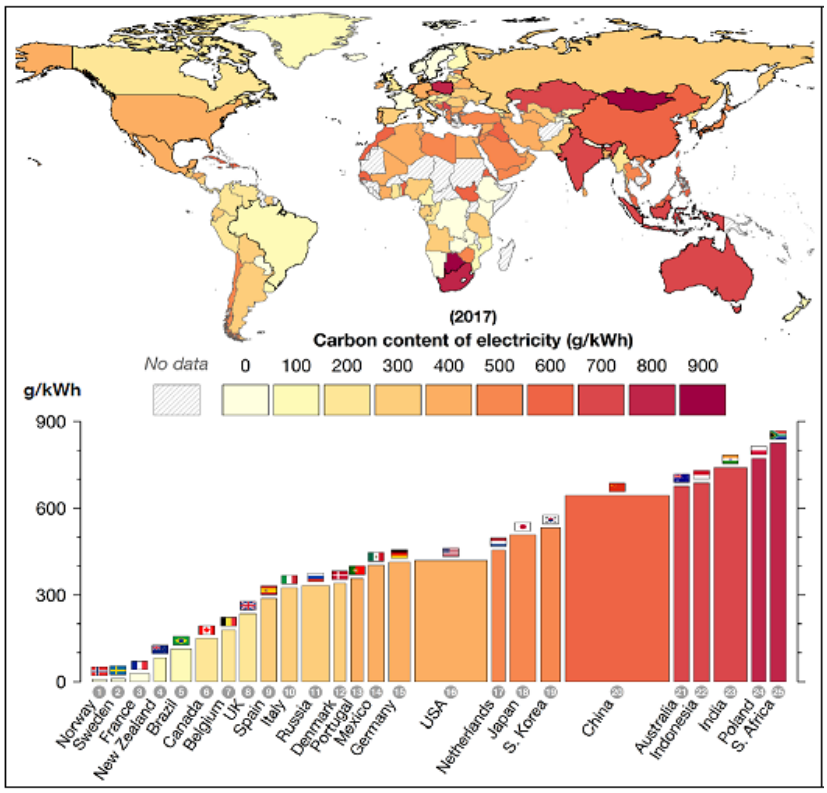

Figure 5. Carbon content of electricity (g/KWh) in 2017.

In 2017, the Brazilian energy sector accounted for 20.8% of national emissions [20], far below the average of that in OECD countries and the other BRIC countries. In fact, taken alone, the Brazilian electric sector is not so significant in the composition of the national GHG emissions. However, factors such as a reduction in illegal deforestation and the energy deficit, besides the electrification of transportation and special final consumptions, associated with a greater demand for refrigeration, should alter such percentages [18,19].

The sector is expected to meet the needs for the expansion of the installed capacity from 158GWp in 2018 to 314GWp, to meet annual demand of 1.159TWh [18,19,21] by 2050. The national electricity sector is set to increase emissions, as observed in the graphs above and corroborated by reports and statements of the Brazilian Government [18].

> PDE2027: (...) Brazil still has a long way to go to achieve socioeconomic standards comparable to those of developed countries. For this reason, per capita energy consumption is expected to increase significantly by 2030 and no trend towards energy sector emissions reduction is expected. Emissions from the sector will be increasing, even with a large share of renewable sources [18].

Brazil predicts an annual increase in emissions of GHG in its energy matrix of 2.8% for the period 2000 to 2020 [18]. However, the path to the goal of + 1.5°C of temperature increase by 2100 presupposes a complete decarbonisation of the electricity sector of all countries by 2030, going far beyond initial commitments made in Paris (NDCs) [3,6,9].

The IPCC and Climate Action Tracker reports indicate that the world is moving towards an increase of + 3.4°C in the average global temperature (range of + 2.5°C to + 4.7°C) [3,6,8]. A second report also classifies Brazil's (NDC) commitment as insufficient to achieve the Paris target and its action weak [8].

Four years after the Paris Agreement on climate change, the Brazilian Government, through the Ministry of Environment, is still struggling with the first draft of the *National Strategy for the Implementation and Financing of Brazil's NDC* [22]. The base document was prepared in 2017 by the Inter-American Development Bank and they estimated a total investment of U$116.4 billion to reach the predicted demand of the 2030 electricity grid [22].

In the energy strategy section, the document [22] foresees U$10.8 billion investments in non-renewable energy generation (U$3.7 billion for nuclear, U$1.1 billion for coal and U$0.1 billion for oil), which is incompatible with a real contribution to the goal of keeping the global temperature *well below 2ºC warming* [3,6,9,22].

Brazil ratified the Paris Agreement on September, 2016, committing to reduce emissions to 1.3 GtCO2e by 2025 and 1.2 GtCO2e by 2030 [8,22], as stated originally in its Intended Nationally Determined Contribution, which is equivalent to 37% and 43% below 2005 emissions levels. This might appear to be much, but the BAU emissions pathway used as reference for the 2020 pledge assumes a high emissions base line and an assumption of 5% annual GDP growth after 2010 [8,22], which is far above actual developments rates [18]. Even so, according to recent studies [8,18,23], Brazil will reach emissions levels of 1.156 MtCO2e in 2025 and 1.198 MtCO2e by 2030 (excluding LULUCF), respectively, 28% and 33% above 2005 levels and 97% and 104% above 1990 levels.

It is clear that Brazil will need to implement additional policies to meet its NDC targets on order to really contribute to the 1.5°C temperature increase goal.

The Brazilian Electric Sector and the evolution of the GHG emission factor

Commitment to international treaties and socio-environmental issues reflect the internal actions of the Brazilian State and are complex issues that will require the special care of the new President of Brazil.

Brazil needs to shorten paths and jump ahead (leapfrogging), change the productive paradigm to incorporate energy poverty reduction and socio-environmental issues into its strategic state planning, innovating in relation to a paradigm established through disruptive technologies [4,11,23]. Disadvantages, such as lack of infrastructure, social and income inequality among others, need to be transformed into opportunities, enjoying the immense potential of renewable energy through new technologies to achieve clean and quality development as quickly as possible, with the generation of jobs and income, a reduction in energy poverty and the preservation of the environment [4,24,25].

Unfortunately, current discourse of the newly elected Brazilian government goes in the opposite direction, from climate denialism to favouring the expansion of the agricultural frontier and big mining and energy projects in the Amazon basin.

The Brazilian Federal Government wants to initiate a new exploitation cycle in the Amazon Region, with the concession of new dams and mines. Already built are Tucuruí 8.535 MWp,

(1984), Santo Antonio 3.568 MWp (2012), Jirau 3.750 MWp (2013), Teles Pires 1.819,8 MWp (2015), Belo Monte 11.233 MWp (2016) and others such as São Luiz do Tapajós (6.356,4 MW) and Jatoba (2.338 MW) are planned, but they have no environmental license to date [18].

However, the Brazilian scenario of increasing hydrological risk due to climate change [26-29] demonstrates that the reliance on hydroelectric is increasingly risky and costly, especially considering the existing environmental externalities involved in the construction of a new dam, with or without reservoirs, and the social impact in the surroundings [10,18,26,28,29].

Currently, much of the lost hydroelectric availability has been replaced by fossil fuel electricity generation, however, the thermoelectric backup system assembled in the last 15 years is based on fuel oil and diesel [18,19] and is expensive and unsustainable. This backup has also proved to be unfeasible as it was designed for sporadic dispatches and is not capable of following the load variation of wind and solar sources. For these reasons the intensity of emissions from the Brazilian electricity grid have been steadily increasing over time [18,19] with the GHG factor reaching 104.4kg/kWh in 2017 [30].

Brazil's capacity of archived 100% feasible renewable electricity matrix in a short run

Sobradinho dam is the tenth largest artificial lake of the world in surface and the first of this kind in Brazil. It has 320 km long; a water mirror of 4214 square km; and a storage capacity of 34.1 billion cubic meters in its nominal quota of 392.50 meters. Constructed between 1973-1979 in the Brazilian NE System, it is an example of conventional hydroelectric storage in Brazil. It is used on a seasonal basis, meaning to store enough water during the wet season to maintain hydroelectric generation during the dry season and droughts.

However, even within full thermal backup turned on, implying highly expensive generation and also a significant rise in GHG emissions, the Sobradinho reservoir hit 1% in November 2017, with flow rate in the dam set at 550 m^3/s, the lowest in its history and less than half of the minimum recommended by the environmental agencies responsible (IBAMA) and National Water Agency (ANA) [31]. The normal average flow of the dam is 2.846 m^3/s. The federal water agency emitted many special authorizations under the recommended limit, until arriving at this minimum flow by Resolution ANA n. 1943 of November 6, 2017 [31]. In fact, it is thanks tothe economic crisis and the rise in wind generation with the installation of 10,081MWp between 2014-2017 [19] that there were no black outs.

Moreover, given the projected growth in wind and solar energy in the NE of Brazil, Sobradinho dam could be used as a virtual water battery and in the future PHS plants with daily storage may also be a viable alternative for storing surplus wind and solar generation in this and other basis [15,32].

Another characteristic of the NE subsystem is that by 2020 it will already lead with a high penetration of variable renewable generation resulting in surplus generation, when wind and solar energy generation shares represent 60% and 4%, respectively. It is estimated there will be more than 5% surplus generation from these technologies [15], especially during low demand periods, between midnight and 08:00h [15,32].

Given the large quantity of conventional hydroelectric storage in Brazil, wind and solar power (with support of biomass generation) can be used to save water in these large hydroelectric

reservoirs (as virtual batteries) and thereby improve energy security [32,33]. If regulated properly, smart arrangements, hybridization of sources and demand side management, it may provide ancillary services and load shifting to balance and support the Brazilian grid [32,33]. This picture could be expanded to Brazil as a whole. In addition to the sum of new transmission lines in the National Interconnected System (SIN - Brazilian grid), energy imports and exports between the regional systems could be optimized, securing supply.

Many studies in the literature [11-14, 20,21] present feasible arrangements and pathways to achieve a 100% renewable electrical matrix.

Current reform of the Brazil's Electricity Legal Framework

The current model of the Brazilian electricity sector, governed primarily by Law 10.848/2004 and its respective regulatory decree, n. 5.163/2004, was conceived in response to the sector's "blackout", which occurred in 2001. After little more than a decade, the sector finds itself in a new crisis of great proportions. New rationing has not yet occurred due to the two consecutive economic crises that have hit the country: the world financial one, which occurred in 2009, and which was followed by the national political crisis, which began in the 2014 elections and extends to the present date [27,34]. The economic stagnation that has occurred as a result has reduced demand for electricity, avoiding a new supply crisis, at least momentarily.

The reform promoted in 2004 by Law 10.488 was also responsible for establishing auctions to contract new energy and thus guarantee the expansion of installed capacity through centralized generation (CG), based on large plants, contracted based on the demands of the distributors, financing the expansion of the sector from these. Between 2004 and 2018, Brazilian installed capacity grew from 90.7GWp to 158GWp [18,19], demonstrating the success of the model, at least in relation to the expansion of energy supply through new ventures.

However, the complexity of the sector and the magnitude of the challenges that lie ahead cannot be underestimated. Sustainability needs to go far beyond the market and greenwashing actions. It is necessary to innovate, to pursue eco-efficiency and sustainable socio-environmental development to make a difference in the present and make possible the fulfilment of the Paris Agreement goals in the future, guaranteeing a global temperature increase to levels no higher than 2ºC.

The reform of the legal framework of the sector (the main bill in the National Congress, number 1917/2015), must overcome business as usual (BAU) and the centralizing paradigm. It should contemplate a new expansion plan that decentralizes the generation and operation [35-39], with one of its main missions being to review the capacity mechanism and the role of the energy utilities, so that they can begin to be understood as companies that provide services and energy solutions. Such companies should act both in the viability of energy delivery and in the management of demand-response, creating negawatts (virtual energy) and meeting the energy needs of the system and its consumers [37-41].

It is also important to open up the market, since greater competition tends to produce better services at lower costs. Spreading the energy supply market, properly regulating the issue of production and sales of energy as services, like solar as services. Such measures have the potential to unlock a new market in the sector, similar to that of television or cable internet.

Suggestions such as the reform of the public call institute (art. 15, §1º of Decree 5163/2004) to boost distributed generation have already been presented in previous studies, publications and public contributions to the Government [23, 35], but they remain outside the bill and off the congress discussion agenda.

DISCUSSION AND RESULTS

The construction of a sustainable future for the Brazilian national electricity sector, which is environmentally correct and economically viable, is based on the implementation of a mix of renewable sources available, as well as a policy that effectively manages the expansion of the installed capacity (new energy), demand-responses (megawatts), guarantees security, supply, affordability and reduces social inequalities. Such objectives are unlikely to be reached based on the principles set out or by the reform proposal presented in National Congress through the bill 1917/2015.

A comprehensive reform is needed to consolidate energy sector legislation and to introduce a new paradigm, aligned with the objectives of Agenda 2030 and the targets of the Paris Agreement. Only in this way, will Brazil be able to contribute to a global scenario where rising temperatures do not exceed 2ºC.

The contribution of the Brazilian Electricity Sector to the climate goals

As shown, the Brazilian electricity sector is not contributing to the achievement of the Paris targets. In fact, it has become more carbon intensive and an increase in GHG emissions in the next few decades is predicted [18,19,30].

For a positive change, the development of a new pathway based on a new paradigm is needed to reorganize the sector and this is unlikely to be reached with the current bill 1917/2015.

Many proposals in the literature to fill this gap and build a bridge to a 100% renewable electrical matrix were examined in this work [11-14, 20,21].

Care about energy eco-efficiency, resilience, quality and reliability of supply, effective equality markets design and sustainable socio-environmental development is a moral imperative for the present generation. Special attention should be given to the Paris climate targets and the Agenda 2030 (SDGs) and their interactions in synergies, limits, feasibilities and goals. Furthermore, in order to increase efficiency in the electricity sector it is important to implement hourly time based tariffs, demand-side management, promote the development of *prosumers* and guarantee a higher penetration of distributed generation in the grid.

Analysis of technical solutions to the Brazilian Electricity Sector in the current context

The implementation of demand-side-management and energy efficiency measures (for example, by using variable speed drives in industry and solar hot-water systems) could reduce peak demand and thus reduce the need for expensive peak-load following ancillary services. Electric hot-water showerheads, widely used in Brazil, could be mandatorily phased out and replaced with efficient heat pump or electric resistance hot-water storage systems that can shift consumption from peak periods to low demand periods. Additionally, where installations are feasible, solar hot-water systems could be encouraged via subsidies.

Furthermore, demand-side-management could be implemented that would enable surplus renewable energy from wind and solar sources to be more easily absorbed into the grid. For example, new regulations could be introduced offering reduced tariffs during hours when surplus wind energy is likely to occur, which is typically in winter and spring between midnight and 08:00h.

In 2018, a time of day based tariff called the *"tarifa branca/white tariff"* was introduced in Brazil which is designed to encourage consumers to reduce electricity consumption during peak demand periods (only between 18:00h and 22:00h).

It is also necessary to deepen sectoral issues such as cross subsidies, costs of use, maintenance and expansion of new capacity, protection, transmission and distribution systems, in order to take advantage of opportunities in a cost-effective way. The construction of a common ground for an understanding of the problem and possible solutions is therefore essential.

The new energy capacity issues, in addition to adaptation and mitigation actions, should be analyzed from the perspective of their impact on the sustainability tripod, incorporating all the externalities, which would allow the search for effective alternatives with lower marginal cost.

The energy transition swift will stress many power assets. In the future various drivers suggest an increase in fossil fuel prices and economic struggle in the fossil fuel industry, whereas renewable sources have low marginal operation costs and falling prices.

Government interventions should not only focus on the short term, they also need to support a managed transition, fair for all involved: environment, industry, commercial sector and civil society, including affected workers. Current drivers of stressed assets already include water scarcity and the financial distress of energy distribution companies, future drivers are likely to include also strict air pollution regulations, carbon pricing and cost-competitiveness of renewables and storage.

The policy of the new elected Brazilian President in relation to the electricity sector and climate goals

The election Bolsonaro for federal government (presidential mandate 2019-2022) made the necessary changes in the environment and climate related issues more difficult to happen. During his election campaign, Bolsonaro flagged opposition to the Paris Agreement, the reduction of GHGs, the maintenance of protected forest areas, ensuring integrity of environmental licensing and cutting fossil fuel subsidies. With important elected State Governors following Bolsonaro's policy position, in states such as Amazonas, Minas Gerais, Rio de Janeiro and São Paulo, it is unlikely to see more ambition or relevant climate actions in the key Brazilian states, where it is most needed.

Brazil will need to reverse its current trend of weakening climate policy to contribute with a global peak in emissions followed by a steep decrease in the coming decades, as required under the Paris Agreement.

Policy of support energy market mechanisms, such as auctions for energy reserves that artificially provide energy reserves (by contracting new plants) instead of recalculating the certification of old ones, dampen and distort market signals, and then negatively affect power costs. These subsidies are the most evident example of many malfunctional taxes and tariffs in the sector that suffers from cross subsidies, countless pendant tariffs and improvised solutions.

Public finance through preferential rates for loans for fossil fuels or the delay or lack of enforcement of policies (such as water, air and soil use and protection regulations) should not be allowed anymore. Continue in the current trend will increase costs in economic and natural capital terms, but also in human lives and species extinction.

As part of an ongoing dialogue policy-makers should consider complementary policies that can ensure the reduction of fossil fuel use and an increase in good practices of circular economy and eco-friendly behaviors. One key element is civil society through sectorial workers and communities. This might include general employment schemes, targeted social protection measures, relocation training and special financing mechanisms.

These measures cannot be regressive, weighing on the poorer in society. A good example may be overtaxing emissions from fossil fuels and subsidizing emissions from modern renewable sources, such as increasing airplane fuel and investing in electric public transport in cities, such as buses, shared car schemes and e-bikes as well as trying to reducing final use tariffs of mass public goods and services.

Solutions can be found by sustaining and strengthening policy implementation in the electric sector, reversing present steps to finance and expand fossil fuel energy sources, and start accelerating climate adaptation, mitigation and energy poverty action.

CONCLUSION

Considering the SDG interactions (positive and negative prospects), the construction of a sustainable future for the electricity sector is upon the enact and enforcement of an effective and rational policy. Opening up the energy markets, incentivising efficient and smart solutions, while also ensuring supply and reducing social inequalities is a possible pathway to pursue. However, the targets are unlikely to be reached without the strong engagement of politicians, citizens, and civil society. Legal arrangements, such as local energy communities could boost popular participation.

The possibilities for the evolution of the Brazilian electricity sector are multiple, but fast implementation in a two approach (both a top down and bottom up process) could accelerate some efforts and synergies and even rapidly reduce poverty. The perspective of execution of projects is high. The adequacy should be made in institutions, system and markets to make green energy generated mandatory and useful, reducing peak demand.

Despite the interest of relevant stakeholders in the national and international arena, achieving good terms in the energy transition will be a great challenge. Technical assistance agencies such as IPCC and IEA are indispensable, but citizens, children, adults, parents,, grandparents and all civil society have to move even faster. Politicians must be put under pressure to do their job in the best interests of the country and the Earth.

The construction of a new electricity paradigm which is decentralized, flexible, more sustainable and efficient is feasible and desired. Digitalization, the use of big data and blockchain will allow technicians to work with unprecedented sets of real time data for learning is expected to solve many future problems.

The potential of energy communities to bring citizens to the energy field and push forward the transition is enormous and local pilot projects are crucial to show how these systems may work in practice, creating and learning about this new business and governance models, as well as improving public perception, acceptance and boarder participation.

The main policy recommendations highlight the ways that research into innovative energy systems and climate change is developing to arrive a net-zero grid by 2050. Actions and policies in this direction sure will create bridges and pathways, helping Brazil to achieve a +1.5ºC Paris target following a consistent path.

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