THE ELECTRIC MATRIX OF THE STATE OF SÃO PAULO TOWARDS THE JUST ENERGY TRANSITION: A COMPARATIVE ANALYSIS OF STRATEGIES BASED ON THE EXPERIENCE OF THE 2014-2015 AND 2021 WATER CRISIS

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Overview

Challenges for sustainability in Brazil's energy system are quite different from those observed in other countries around the globe. It ranks first in the world on total renewable water resources at around 8,6 trillion cubic meters available per year, almost twice the second place (Russia with 4,5 trillion) and representing about 15,7% of the global total. This wealth also turns it into one of the top countries in hydroelectric potential, estimated at 172 GW, of which about 60% is already being used. Consequently, the participation of renewable sources in the Brazilian energy matrix is very significant, especially in comparison with other major economies. In 2021, renewables represented 46% of Brazil's primary energy consumption, a share far superior to the observed consumption for the OECD countries of 15%. This is reflected in the profile of the country's greenhouse gas (GHG) emissions, in which energy-related emissions are not predominant and mostly come from the transport sector. Thus, Brazil's energy transition strategies must consider these fundamental differences and the contradictions and limits present in the current system configuration. With the goal of decarbonizing the generation of electricity largely fulfilled and the fast growth of solar and wind participation on a predominantly hydro-powered matrix, there is still work to be done in assuring the diversification of sources and the security of the system. In addition, social issues must be addressed when considering a genuinely sustainable vision for the energy system, and this is a matter Brazil still is far behind. With a history of silencing and violation of rights in high-impact energy projects, environmental justice must be a major concern for shifting the country towards a just energy transition.

In such context, the present paper analyses the evolution of the electric matrix of the Brazilian state of São Paulo, between 2012 and 2022, through the lens of the just energy transition, focusing on distributional justice issues. Two major water crisis events that occurred in 2014-2015 and 2021 were more thoroughly analyzed to assess their impacts on the state's electric system.

Methods

To evaluate the availability of electricity in the state and the impact of both water crisis on electric generation, generation source and the types of acting of the plants, using public data from Brazil's National Electric Energy Agency (ANEEL), characterize the evolution of the installed capacity of the state's matrix in the period. In comparison to the installed potential, the electricity effectively generated inside the state in the period is assessed considering the different generation sources through data from the National Operator of the Electric System (ONS) and data from the 2022 energy balance produced by the state's government. Also, the state's hydroelectric system is further investigated through the average reservoir's live storage of the state's 4 generation chains, which corresponds to it' main drainage basins: Tietê, Paraná, Paranapanema and Grande. The effective volume available in each chain is calculated from 2012 to 2022 through a weighted mean of each reservoir effective volume in the period, with the weights being the reservoir's energy storage capacity ratio in relation to the subsystem's total capacity. It is worth of notice that reservoirs outside the state were considered in the Grande chain analysis, as these reservoirs are vital to discharge regulation in the basin and therefore cannot be left out. From the comparison the impacts of both water crisis are evaluated, as well as the effects of the state's energy planning on the evolution of the electric matrix.

Results

Renewables already make up most of the Gross Domestic Energy Supply in the State of São Paulo, with a participation of 58.5% in 2021. São Paulo's large sugar cane agroindustry reflects on the growing participation of sugar cane products on the supply, at 32.7%, while hydraulic and electricity made up 18.7%. Still, the remaining 41,5% of fossil fuel energy, consisting primarily of petroleum and derivates (33%), with a significant amount of gas usage (8,5%), represent a deep and structural challenge for energy transition, considering the main uses of fossil fuels in the state. The transportation sector is by far the largest consumer in São Paulo, which, like most states in Brazil, still has a large dependency on motor vehicles, relying on its fleet of more than 32 million vehicles. The use of fossil fuels in thermoelectric power plants is only a small fraction in comparison, but these plants play a vital role on the state's electric system stability.

Both water crises notably influenced costs and tariffs in the Brazilian electric system, noticeably in São Paulo and the Southeast/Central-West electric subsystem. The taxes in Brazil are submitted to a "Tariff Flag" system since February 2015, which operates through five different levels of pricing (Green Flag, Yellow Flag, Red Flag 1, Red Flag 2, and Water Scarcity Flag) that are defined according to the availability of electricity from hydroelectric sources. Specifically, the ANEEL defines it through the Settlement Price of Differences, which is calculated through models and published daily by the Electric Energy Commercial Chamber. This value is closely related to the Marginal Cost of Operation, which represents the cost of generating the next unit of energy (MWh) the system requires to meet its demand.

Conclusions

Significant challenges are ahead for a fair energy transition in São Paulo and Brazil, as this focused analysis on the state's electric matrix attempted to show. Even though Brazil achieved many advances in decarbonization, the dependence on hydroelectric generation ultimately means fossil dependence. Current energy planning in São Paulo, while referring to the state Climate Change Policy, does not show any strategies for tackling this dependence.

In conclusion, a fair energy transition in São Paulo and Brazil requires pushing for significant structural changes in the established status quo of hydraulic and fossil dependence. The latest Assessment Report released by the IPCC [40] demonstrates that the severity and frequency of extreme climate events, including droughts, are virtually sure to increase with the rise in global temperatures, making the halting of emissions an imperative and exposing the necessity to build greater resilience in face of the climatic extremes. In the face of the imminence of this challenge, policies, and planning remain insufficient for developing a large-scale renewable alternative for breaking the hydraulic and fossil dependence in a way that guarantee availability, affordability, and equity among the many different actors in the electric system.

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