AN OVERVIEW OF THE BRAZILIAN ELECTRICITY SECTOR

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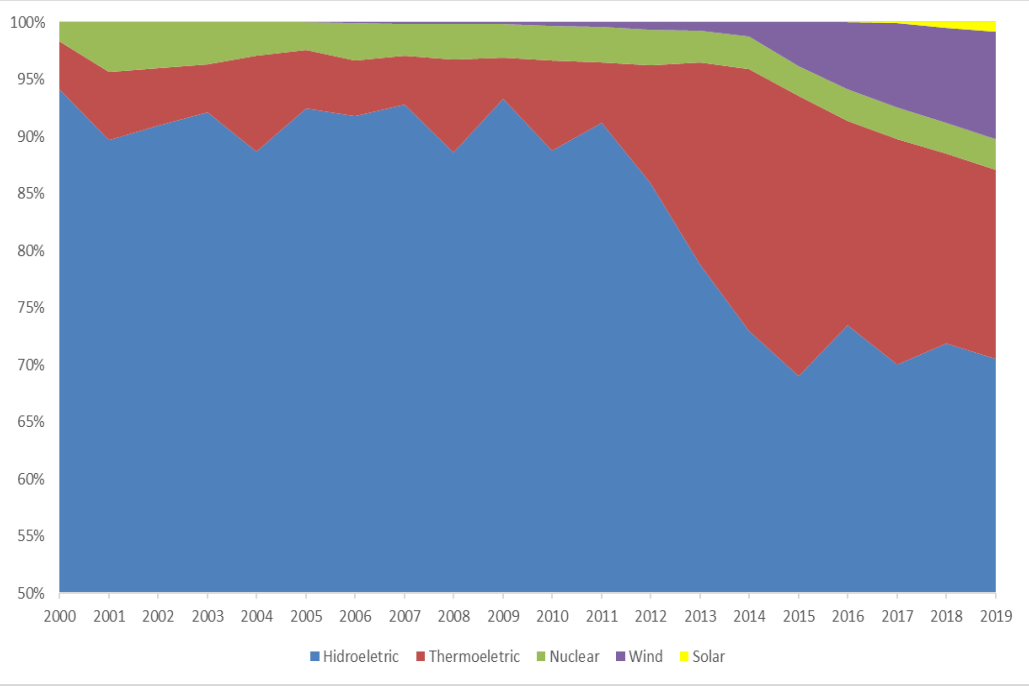
Brazilian Electricity Sector: An Overview

- Brazil is a **large country with regard to continental** distances and its sizable power system, both in terms of generating capacity and grid extension.
- A **prominent feature of the Brazilian power system is the participation of hydropower,, similar to Canada, Norway and Colombia**
- However, unlike in these countries, most of the hydropower capacity in Brazil is **associated with large reservoirs**, which work as energy regulators.

Brazilian Electricity Sector: An Overview

Figure 1: Share of Electricity Generation by source



- **Brazilian Electricity Sector (BES) is a hydro-thermo-wind system**, with a predominance of hydraulic generation (70%), followed by thermoelectric generation (20%).
- As of 2020, the **installed capacity in Brazil is about 190 GW** and is composed mainly of hydroelectric plants (63%) distributed in sixteen hydrographic basins. Thermoelectric plants represent about 27% of the total.
- **Wind farms** represent **7%** of the total installed capacity and have been increasing their participation in generation.

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- The **thermoelectric** connected to the National Interconnected System (NIS) are **dispatched according to the hydrological conditions**, allowing the management of the stored water stocks in the reservoirs of the hydroelectric plant in order to ensure future supply.
- The situation in Brazil is different from that in Europe, for instance, where the baseload plants are generally conventional gas-fired power plants
- In **Brazil, only Nuclear power plants run on baseload.**
- **Natural gas thermoelectric plants provide mid-merit generation** and **oil-fired** plants only **work in peak hours.**

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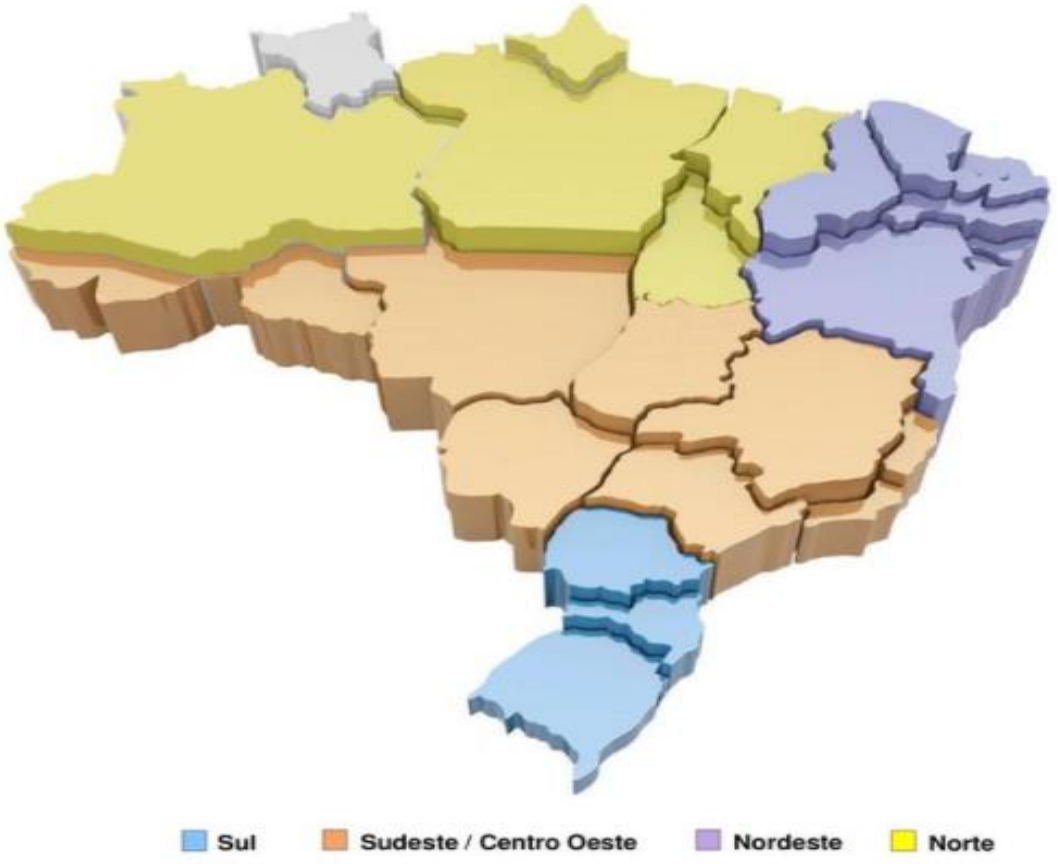

- The Brazilian Electric Sector (SEB) is divided in two (2) systems: one interconnected (NIS) and one isolated;
- and four (4) subsystems namely: Southeast/Midwest, South, Northeast and most of the Northern region.
- BES is manly private, but still coexist with state owned companies in all subsector (Generation – Transmission – Distribution).

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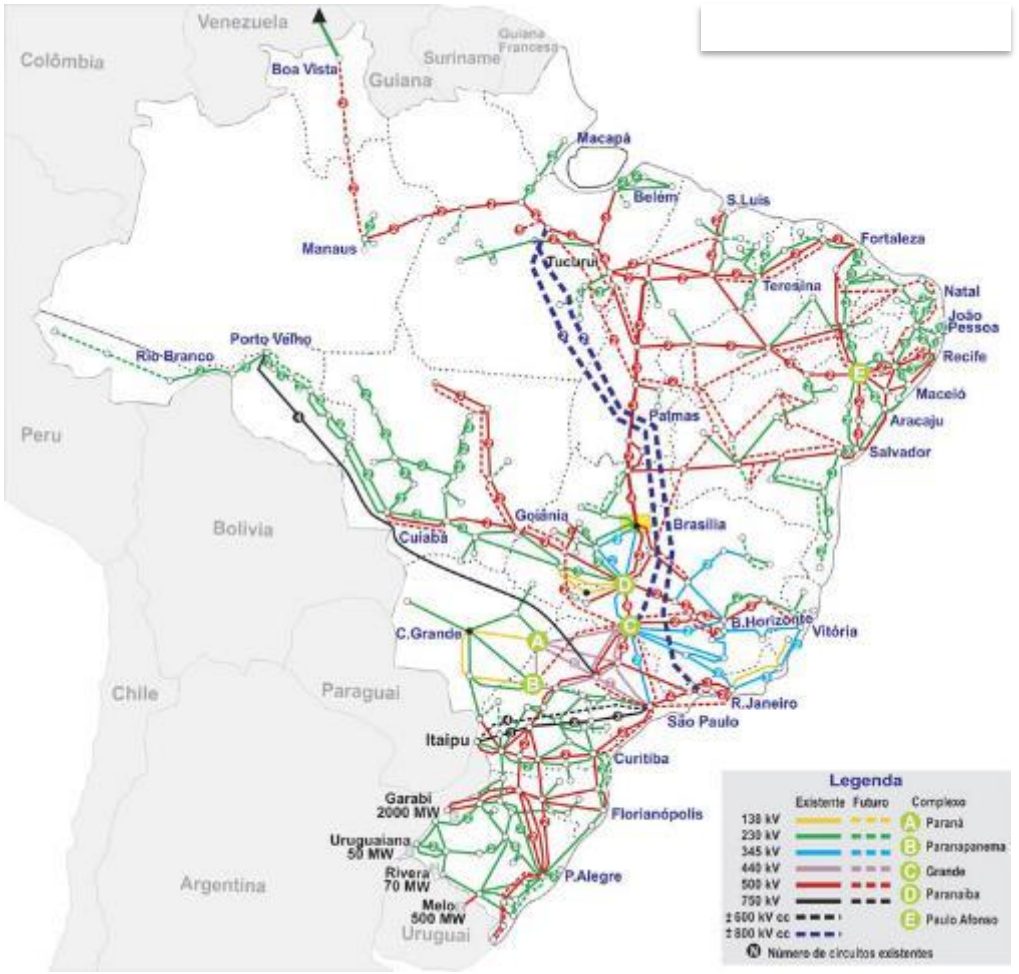
- The National Interconnected Power System (NIS or SIN in the Brazilian acronym) consists of 140 hydropower plants, which have capacities ranging from 30 MW to 14,000 MW, that are located in a dozen river basins throughout the country and are interconnected in a transmission system with more than 180,000 kilometres of lines at 230 kV and above. By applying certain technical configurations, the energy generated in any part of Brazil can be consumed in distant regions of the country.



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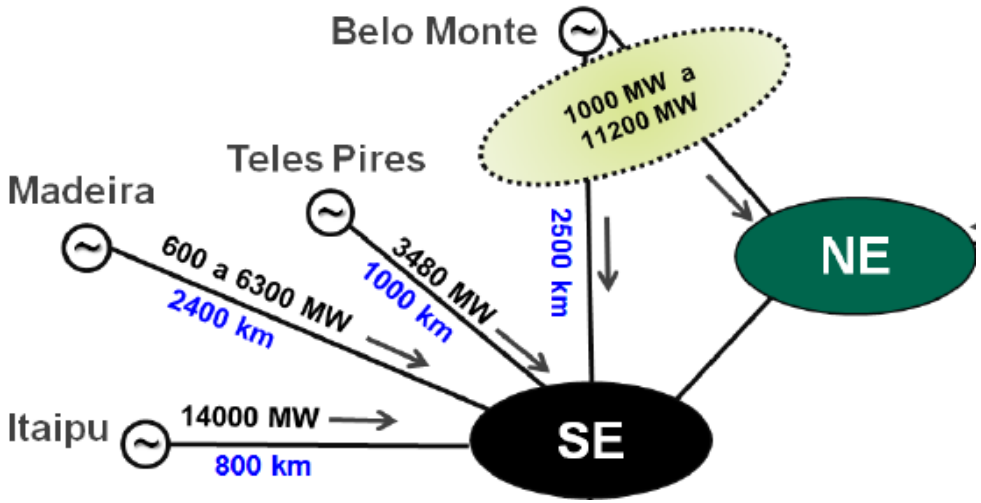


- Figure above shows the extent of the transmission lines of some of the most recent and relevant hydro power plants, such as Belo Monte, in the Xingu river basin; Jirau and Santo Antônio, both in the Madeira river basin to the consuming markets in the Southeast

- The interconnection originates from the notion that Brazil operates a hydroelectric system composed of water reservoirs and hydroelectric plants that were planned in such a way that they could take advantage of the fluviometric diversity in the existing basins, which have various weather and streamflow patterns.
- For example, when the well-known climate phenomenon El Niño occurs, the northeast region faces droughts, whereas the southern region has increased rainfall
- This measure ensures an important energetic gain for the Brazilian system.

Market Structure

BES has two environments for the commercialization of electricity: (i) Regulated Contracting Environment (RCE); and (ii) Free Contracting Environment (FCE).

At **the RCE** (70% of total market) energy and new capacity is bundled contracted through Auctions by Distribution Companies. Contract bids in these auctions are for periods between 15 years and 30 years depending of the source. The long-term energy contracts were created to attract investment in generation, in a country with high load growth. Long-term contracts also have the effect of reducing the incentives for generation companies to manipulate output and prices in spot markets.

On the other hand, at the **FCE,** (30% of total market) negotiations take place freely among generators, marketers, and free or special consumers. The price is set by the market and can be adjusted freely according to agreement, need and interest between the parties. Term deadlines are also variable and not necessarily consecutive, as well as amounts.

Consumers who purchase energy from incentives sources, such as biomass, run-of-river hydropower, wind and solar, are entitled to a reduction of between 50% and 100% in the tariffs for the use of the distribution system (TUSD) and transmission (TUST). The discount on distribution and transmission tariffs is an economic incentive for the development of renewable sources in Brazil.

The differences between the two markets and the STM

- The differences between the amounts of energy contracted and generated in the two contraction environments are settled in the **Short Term Market (STM), the Difference Settlement Price (PLD).**
- However PLD is not determined by market forces.
- PLD is determined by optimization software based on Marginal Operating Costs (CMO).
- Furthermore PLD has a minimum a maximum level in order to avoid extreme prices

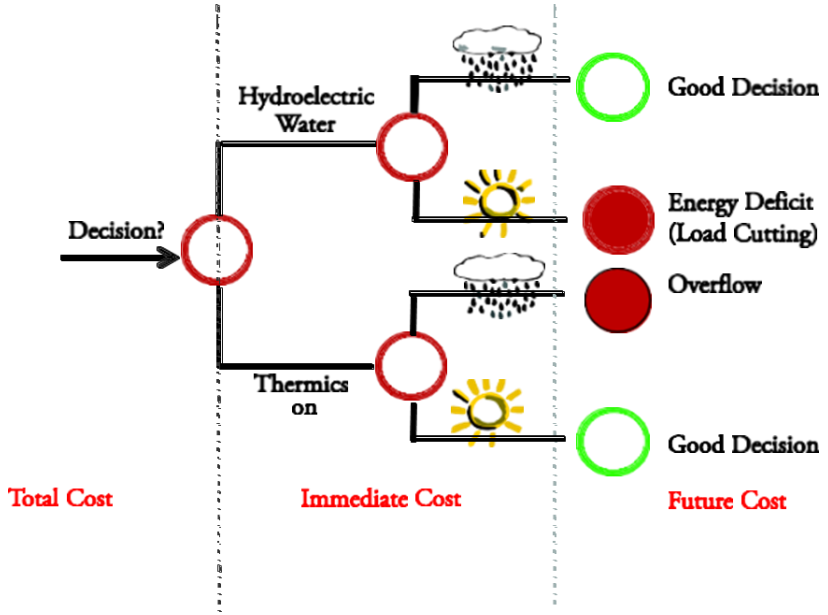
	Players	Contracting Instrument	Type of Contract	Price
RCE	Generators, distributors and traders	Auctions	Regulated by Agency	Established at auction
FCE	Generators, traders and free and special consumers	Free Market	Freely established between the parties	Freely established between the parties
STM	Generators, distributors,traders, free and special consumers	Difference Settlement Price	None	Difference Settlement Price

Centralized Dispatch Model

- In order to take advantage of the territory **pluviometry diversity** in the existing basins, which have various weather and streamflow patterns, the National System Operator (**ONS**) **dispatches the entire hydro-thermal system as a "portfolio,"** with huge energy blocks being transferred from the "wetter" regions to the "drier" ones.
- This **optimization of the use of hydroelectric and thermoelectric resources is carried out with the use of stochastic scheduling models**.
- **This dispatch model does not consider any environmental externality, such as GHG emissions**

Centralized Dispatch Model

- In contrast to purely thermal systems, in which the operational planning problem can be simply resolved by establishing a pattern among the plants to minimize fuel costs, when discussing the operation of hydrothermal systems, the future of available hydroelectric generation is uncertain, and the decision is coupled with time; that is, a decision made today will have consequences in the future. For example, if a significant hydroelectric dispatch exists before a dry period, there will be a risk of high-cost thermal dispatches in the future. Conversely, a thermal dispatch before a wet period may cause overflows, which will result in wasted energy (see Figure below)

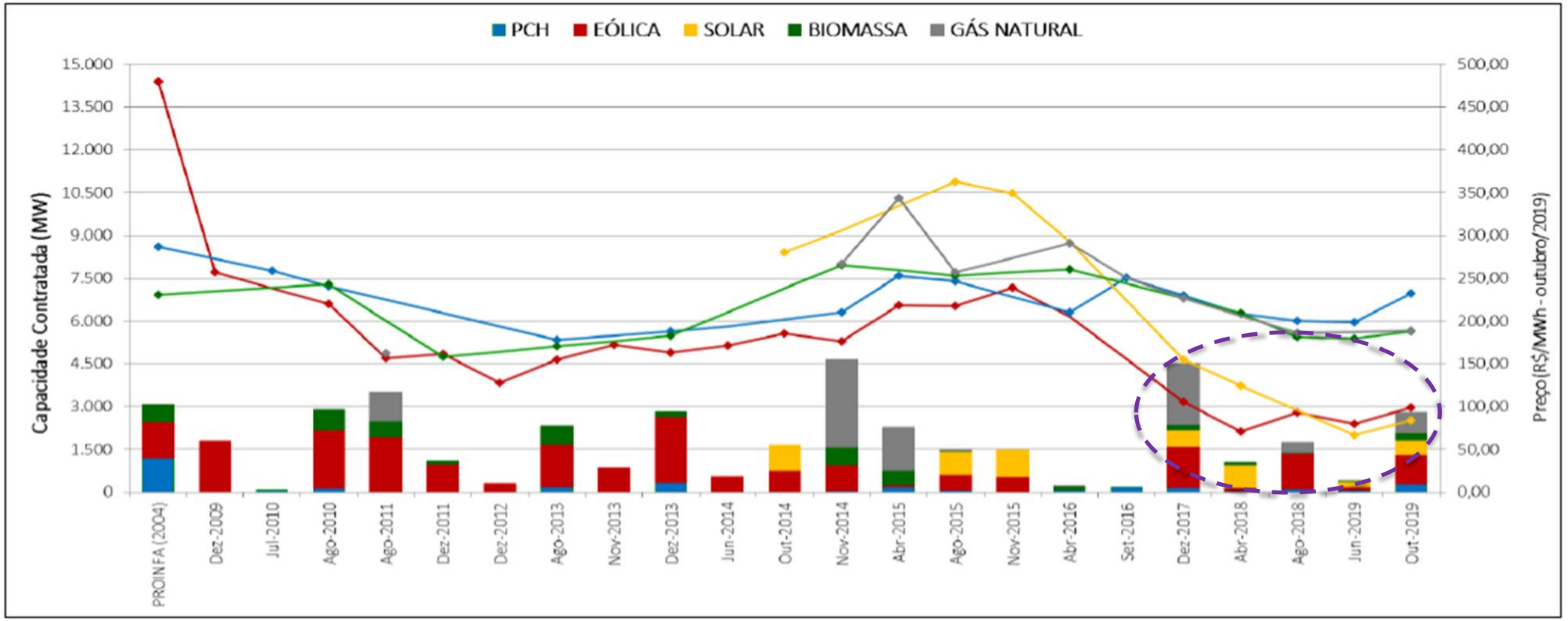


Thus, a balanced operation of the system involves multiple compromises between depleting (using water) and not depleting (using thermoelectric power plants) the reservoirs. The decision variable is the volume of water stored at the end of the operational period (final volume)

For next 10 years, the government is planning to phase out all diesel and oil plants and replace them by NG plants

Renewable are highly subsidize

- Incentives sources, such as biomass, run-of-river hydropower, wind and solar, receive about US$ 3 billion per year in cross-subsidies. Moreover, Coal Thermoelectric also receives about 300 million per year.
- However, such subsidies are being questioned since these sources, specially wind and solar, already have competitive energy prices, as you can see in the figure below

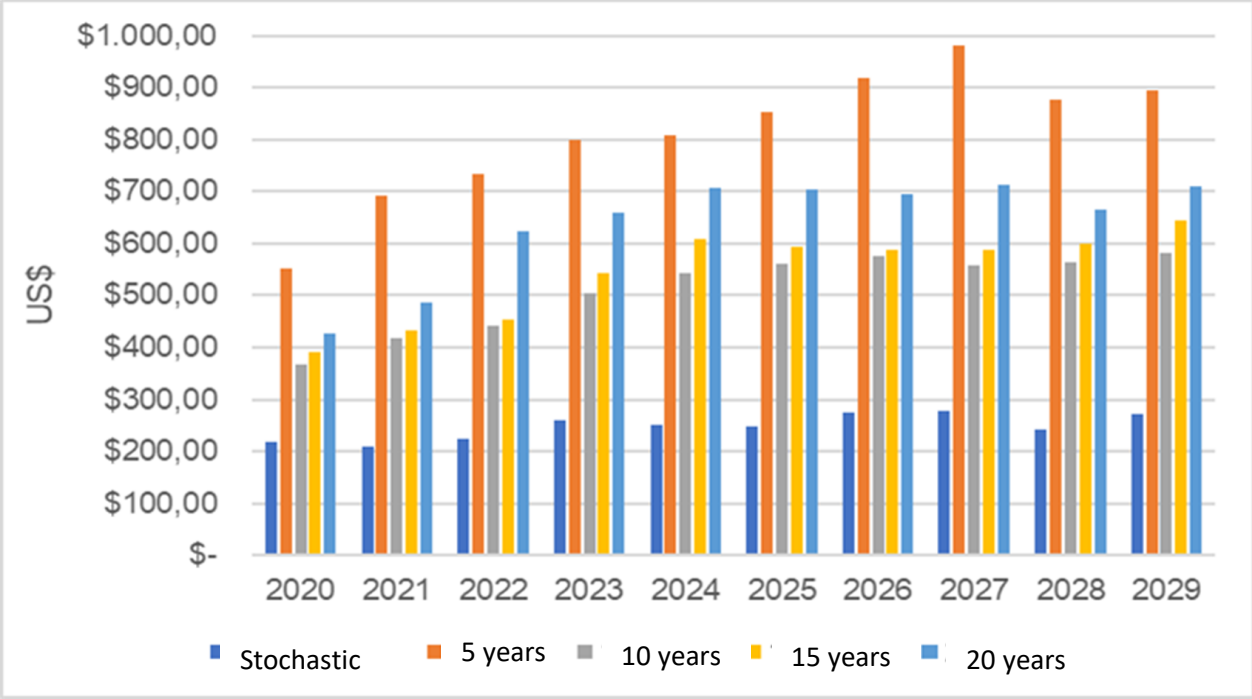


New Market Structure is being discussed

- Given that:
  - Free Contracting Environment is growing faster
  - Variable Renewables sources already have competitive prices
  - It is expected an increasing thermoelectric dispatch in the next 10 years due to meteorological conditions and increasing share of variable energy in the energy mix
  - Bundle contracts (energy and capacity) are not necessary anymore due to better financing conditions

- A New Market Structure is being discussed
- Main goals are:
  - Increasing the share of Free Market
  - Let the prices be determined by market forces instead of optimization softwares
  - Create an Energy-Only Market and also a Capacity Market (unbundle contracts)
  - Choose an instrument to value environmental attributes for different technologies (carbon pricing, particularly ETS, in on the table)

Recent studies point that there is a 50MtCO_2e of Potential Carbon Market on average per year in Brazil for the next decade



- The study projected five dispatch scenarios considering different rainfall patterns between 2020 and 2029.
- Results point that if emission were auctioned by the world average allowance prices observed in 2019 (US$ 10), the government could raise US$500M on average, reaching over US$800M.

Final Remarks:

- The Brazilian Electricity Sector is not completely liberalized
- However, it does not present those classic passthrough barriers for carbon pricing, such as wholesale price control, administrative dispatch, among others
- Current market structure would support carbon pricing by introducing a price signal in the dispatch and CP could be easily passthrough to final consumers
- In the presence of carbon pricing, cross-subsidies for variable renewables sources should be reviewed and social impact should be considered
- However, a new market structure is being discussed in Brazil and there is a broader room for carbon pricing initiatives, particularly an ETS
- Some studies indicate a great potential for Recycling Revenues that could support both Jut Transitions and Net Zero initiatives

Thank you

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