

Study Committee C5 Electricity Markets and Regulation C5

Paper ID_10172

Application of Capacity Market Mechanisms – Security & Resilience for Brazilian Power Markets

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Motivation

- The Brazilian Federal Government and the Legislative passed Law No. 14,120/21 to implement the Capacity Market. The main objective is to ensure safety and resilience for the future operation of the power system.
- A central auction to contract capacity in the market is regularly done with requirements based on adequacy and safety targets, already approved by the Federal Government through the National Energy Policy Council (CNPE).
- The Capacity Market implemented is a practical solution with a marginal hiring approach, where new and existing strategic assets will compete.
- System operation over the next 10 years, considering reliability requirements, will be truly challenging, as many of thermal power plants can be decommissioned, and the safety and resilience of electrical system operations will be compromised with the increasing integration of renewable sources intermittencies.

Implementation of Capacity Market

The paper investigates the calculation of the future capacity needed to meet the CNPE (national council of energy) criteria, based on reliability targets.

A case study is presented to demonstrate the new requirements for capacity generation services in the Brazilian system, based in the following:

- There would be a marginal Capacity Market, in which only the resources for the reliability improvement of the Brazilian market would be contracted and not so competitive in energy-only market.
- The capacity market should only provide the revenue for those projects cannot obtain it in the energy-only market, with a rate of return required by investors.
- As market agents currently obtain incomes in the energy-only market through contracts, or by settling the PLD (spot price), the formation of energy and capacity prices is essential for system security.
- The calculation of reliability CNPE targets are probabilistic criteria, and the assessments must incorporate the main uncertainties of the Brazilian market.
- The modeling to calculate the necessary quantities of new capacity supply to meet the CNPE criteria must include: (i) uncertainties of the capacity supply; (ii) load curve representation; (iii) forced outages and repair of generator units using stochastic data; (iv) reliability simulators.

Sources and Capacity Products

The Figure 1 illustrates a separation of “energy” and “capacity & reliability” products linked to sources and their attributes.







<i>sources</i>		<i>products</i>
 Wind	 Solar PV	Energy
 Biomass		
 Fast response – Thermal plants High variable costs		
 Hydro oversupply without energy		Capacity/reliability
 Hydro	 Base and mid-merit – Thermal plants	Energy & Capacity/reliability

Figure 1 - Sources and Products – Capacity Market Implementation in Brazil

The Brazilian planner (EPE) is responsible to support the capacity auction calculations and the suggestion presented in Figure 1 by authors aims to precisely incorporate operational aspects to provide more and more flexibility in the future operation. Hence, it is necessary to define which projects are eligible to improve the resilience and security of the system.

The Brazilian energy matrix has been changed in recent years, a trend that should intensify in the future considering the competitiveness of new renewables.

Conclusion

- Contributions about the calculation methodology for capacity reserve auctions based on in-depth technical studies are presented in this work.
- The new Brazilian market design is a “capacity market” arena, with different products – capacity requirements paid by all final users and an energy-only market with a large set of products negotiated as required by final users (ACR regulated branch and ACL liberalized branch), traders, generators, financial institutions.
- This new market design marginally contracting assets as a capacity product. The target with the application of Capacity Market Mechanisms is to ensure security & resilience for Brazilian Power Markets.

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Rational of Brazilian Capacity Market

In a context of abundance of the energy component, reflecting a low price, there may be an unusual situation of scarcity of other services necessary for the reliability of the system. The fast growth of renewables in Brazilian market is promoting this framework.

International experience points out as a solution to this phenomenon with the creation of a capacity market, considering the necessary services and their contracting, to find a combination of assets and resources that allow competitive costs with an established level of security.

The new expansion auctions must meet the needs of a capacity market – electrical and energy adequacy and security – differently from the current expansion to meet only the energy requirements of consumers.

A solution is a hierarchical competition process for the selection of the future matrix – contests to meet the requirements in a sequential process.

The complementation of needs must be carried out in a long-term to short-term vision with ancillary services market.

The Figure 2 demonstrates the market principles and their capability in meeting market requirements in the new Brazilian market environment.

It is understandable that the revenues for the capacity revenues must be covered by all final users (ACL and ACR), given power system reliability is a “common welfare” for all market participants.

In this new market design, the capacity of the technologies, with the proper attributes for the security of the system, would initially be contracted centrally, based on technical studies coordinated by the MME (minister of energy), carried out by EPE (planner) and ONS (operator), with regulation of the process by ANEEL (regulator) and market implementation of the CCEE (market administrator), which would make concrete the provision established in Law No. 14,120/21.

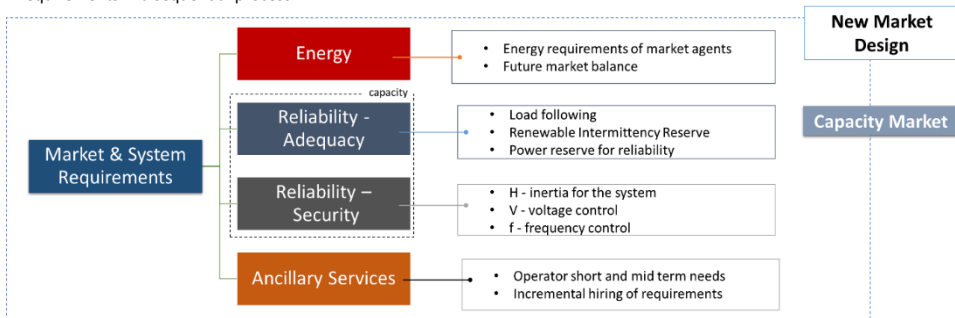


Figure 2 - Market Requirements – Enhancement with Capacity Market

Evaluation & Supply Criteria

The task of planning a resilient electrical system is increasingly challenging given the growing complexity of uncertainties, scenarios, disruptive technologies, and climate change.

The responsibilities of the Granting Authority and the system planner increase their commitment to understanding the physical reality of the Brazilian power systems.

This new request was already identified with the massive entry of intermittent renewables in retail and wholesale, in addition to other run-of-river hydro sources without storage capacity. The fact base is Brazilian market became increasingly dependent on sources with great variability of the primary energy resource, subordinating itself to nature and potential climatic events.

Hydro supply is still a biggest share in Brazilian matrix (around 60%) and is facing underperformances due to severe drought season. The recurrent depletion in the reservoirs can force a concrete possibility of loss of hydro control and power capacity deficit.

The calculation of the maximum power availability of hydro plants to be considered in the balance of future capacity in the SIN must be improved.

The importance of projects for power adequacy can be demonstrated by the value added in the power system reliability.

To meet the CNPE's probabilistic criteria in defining the adequate capacity of the Brazilian market, a broad assessment of the uncertainties in the operation is necessary – a probabilistic analysis.

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Case Study - Data

A case study in the horizon 2025-27 is developed to present the applied criteria to define capacity market requirements and very comprehensive dataset is applied, as detailed below:

- Failures and Repairs – hydro and thermal plants units are considered
- Hydro Capacity Availability - synthetic hydro series based on historical data, creates a large set of hydrological sequences, which are sampled in reliability model (see Figure 3) for reservoirs, run-of-river, and giant hydro plants considering the reduction in head due to depletion, and consequently loss of capacity in hydro units. A large of variation (70 to 100%) can be observed.

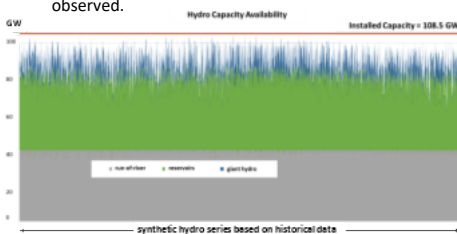


Figure 3 - Hydro Capacity Monthly Variations

- Renewable Production Availability - The production of renewables – wind and utility-scale solar PV – is simulated in detail and all intermittences are captured from historical time series. Figure 4 illustrates the hourly variability of wind production in the Northeast and South regions, and for utility-scale solar PV production in the Northeast and Southeast, where projects are in Brazil.

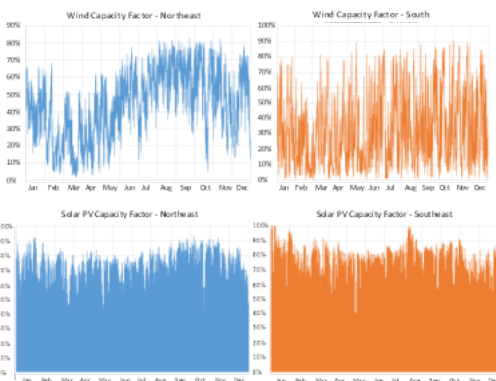


Figure 4 – Wind and Solar PV Hourly Variations

Results

Combining capacity deviations of all sources, as presented in Figure 5, the variations have different levels of influence in the whole system capacity availability. The reduction of capacity is critical comparing to full capacity and certainly has impact in the system adequacy and security.

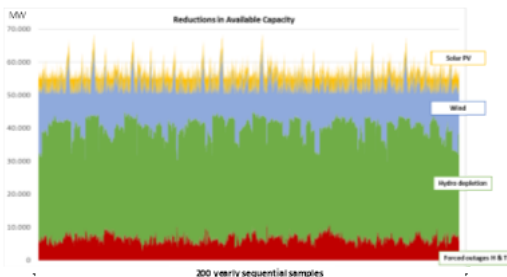


Figure 5 - Reductions in Available Capacity in Simulation

The capacity requirements calculated to meet the CNPE criteria in the 2025-27 is a reasonable volume as summarized in Table 1, when applying the suggested methodology.

Table 1 – Need for Capacity Reserve Contracting (MW)

System Requirements - Capacity Auction (MW)	With Nuclear Angra 3 - 2027			Without Nuclear Angra 3 – 2027 (COD postponement)		
	2025	2025-27	2025-27	2025	2025-27	2025-27
Forecasted Demand						
Reference	6.250	5.763	12.013	6.250	6.803	13.053
Superior	10.800	9.964	20.764	10.800	11.295	22.095

Revenues to support the capacity requirements through public auctions are covered by whole market consumption named capacity reserve charge (ERCAP), around R\$ 10 / MWh (~ 2 US\$/MWh). The benefits for final users are higher than the expected new charge, given the reduction of price spikes or the dispatch of more expensive thermal plants, as a last resort to avoid unbalance of supply.

Conclusion

- Contributions about the calculation methodology for capacity reserve auctions based on in-depth technical studies are presented in this work.
- The new Brazilian market design is a “capacity market” arena, with different products – capacity requirements paid by all final users and an energy-only market with a large set of products negotiated as required by final users (ACR regulated branch and ACL liberalized branch), traders, generators, financial institutions.
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