ON THE PATH OF INTEGRATION OF THE ELECTRICITY MARKETS OF THE SOUTHERN CONE

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Overview

This work describes the recent history of electroenergy exchanges between Argentina, Brazil, Paraguay and Uruguay and how they have evolved accompanying the changes in the different countries.

Both Argentina, Brazil and Uruguay have markets with centralized dispatch based on variable generation costs. In the case of Paraguay, given that it shares the two binational power plants Itaipú and Yacyeretá with Brazil and Argentina respectively and that its share in these power plants is still much higher than the country's own consumption, it is difficult to speak of a market arbitrated by a cost marginal.

Uruguay transformed its generation matrix between the years 2014-2018 by aggressively incorporating wind and solar energy (G.Casaravilla and R. Chaer, “Energy Transition of Uruguay, IAEE Energy Forum,” p. 11.). Although Uruguay was a pioneer in this change, driven mainly by the need to reduce hydrological risk and fossil fuel prices, the incorporation of wind and solar energy is a global trend, adding to the aforementioned reasons the commitments to reduce emissions. of greenhouse gases. These energies, which present low dispersion on a monthly and annual scale (compared to hydrological variability), present important variabilities on a daily scale. The wind and solar generation forecasts are very good in the horizon of the next 72 hours, which creates opportunities to schedule exchanges between countries to take advantage of the eventual complementarity of resources.

In recent years, Brazil has incorporated significant amounts of wind and solar energy in large-scale generating plants, but an aggressive installation of distributed micro generation is also underway. These changes place the Brazilian system in the need to foresee how to compensate for variabilities. In particular, the massive installation of distributed solar energy will lead to demand having the well-known "duck curve", changing the use of the transmission network, causing the requirements on it to shift outside of the hours of high solar radiation.

In the case of Argentina, the incorporation of wind and solar energy has also been registered, but according to the expansion plans published by the Ministry of Energy, it is based on the installation of thermal power plants fueled by natural gas mainly associated with development. of the Vaca Muerta deposits.

Much work has been done and progress has been made to improve the use of existing capacity and in the last 5 years we can say that an offer mechanism has been established based on energy blocks with prices between Argentina, Brazil and Uruguay that has allowed, for example, that Argentina and Uruguay would be exporters and Brazil would be importers during 2021 and that in the following years the hydrological situation would be reversed and Argentina and Uruguay would become importers mainly of hydraulic energy from turbine discharges from Brazil. Without a doubt, the demands imposed by the extreme events of hydroelectric resource availability experienced in these years contributed to improving exchange mechanisms.

As an example of these situations, it seems interesting to reproduce here the following text extracted from page 92 of the Ten-Year Energy Expansion Plan 2031. Ministry of Mines and Energy, Secretary of Planning and Energy Development (https://www.epe.gov. br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2031):

"Por fim, o PDE vem seguidamente abordando a importância, para o Brasil e região, da integração energética com os países vizinhos. A inédita situação hidrológica brasileira demandou não apenas novas medidas locais para garantir o suprimento como conduziu a abertura para intercâmbios energéticos em níveis inéditos. Dados da CAMMESA, ADME e ONS indicam que a importação brasileira de energia elétrica a partir de Argentina e Uruguai somou de janeiro a novembro de 2021 aproximadamente 6.000 GWh."

The events of rainy and dry years differentially between countries generate the situations of greatest benefit and cost and supply risks. Situations that have undoubtedly driven the search for improvements that enabled new exchange modalities. As an example, for imports made in 2022 and 2023 by Argentina and Uruguay from Brazil, Brazil's authorization of the export of turbineable hydraulic discharges was crucial.

But it is also important to highlight that the hydroelectric resource is strongly correlated in the region. The years in which the El Niño phenomenon occurs tend to be with abundant rains and the Niña years with little rain in the southern region of Brazil and in the basins of the Paraná and Uruguay rivers. Therefore, solutions must be sought, complementary to those already achieved, that enable more exchanges between systems in the most frequent situations and not only in extreme ones.

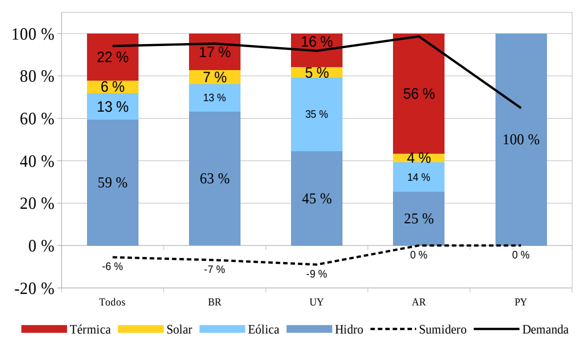

Fig. 1: Generation matrices projected to 2030

In theory, energy should flow through the interconnections, from the node with the lowest marginal cost to the node with the highest marginal cost, increasing the level of exchange until either the marginal costs equalize (taking into account loss factors) or it reaches the limit of exchange capacity. This paradigm that would lead to the optimal use of the resources of the whole presents restrictions in practice due to the organization of the markets in each country. The exporting market may be making energy more expensive for its consumers and increasing the profits of its generators and vice versa in the importing market. These effects on the costs/remunerations of the internal agents of each country are usually the basis of the difficulties for exchanges outside of extreme situations.

In addition to the possible impact on the remuneration of the agents in each market, the high hydroelectric composition of Brazil and Uruguay leads these countries to be cautious in the management of the energy stored in their reservoirs. The operation of reservoirs is associated with complex optimization processes (solving stochastic dynamic programming problems) that valorize the impounded water. Implicit in this valuation is the medium-term energy security of the systems. For this reason, countries are reluctant to export reservoir energy. In addition, in the case of Brazil, associated with what is known as the Energy Relocation Mechanism, the import of energy that replaces hydraulic generation is prevented because the hydroelectric group must also receive the expected remuneration.

Methods

In 2022-2023, the World Bank carried out the study: "Impact of climate change on electricity generation in the countries of the Southern one" in which a fairly detailed SimSEE model of Brazil, Argentina, Paraguay and Uruguay was implemented.
(https://www.bancomundial.org/es/region/lac/publication/impacto-del-cambio-climatico-en-la-generacion-electrica-en-los-paises-del-cono-sur)
This SimSEE model was made available, publicly and free of charge, at the address:
(https://sourceforge.net/projects/simsee/files/CambioClimaticoUYBRPYAR/)
The details of the systems modeling are found in the annex:
(https://documents1.worldbank.org/curated/en/099617108212321695/pdf/IDU0a989396f072e90437808280082e8efc5112f.pdf).

To carry out this work, this model was used in the base scenario (that is, without climate change) and the results correspond to the structures of the systems projected to 2030, maintaining the current restrictions on exchanges.

To take into consideration that the countries do not export reservoir water, and that in the case of Brazil it does not import energy that replaces hydroelectric generation, a barrier to exchanges was introduced by imposing a difference (Delta) of at least 60 US$/MWh for for an exchange to happen.

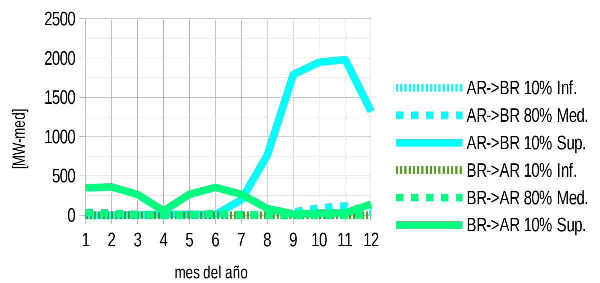

Fig. 2: Flows through interconnections in systems with the structure of 2030

Results

Fig.1 shows the generation by source according to the structure of the systems projected by the countries to the year 2030. As can be seen, Brazil and Uruguay continue with an important hydroelectric base (63 and 45% respectively) while in Argentina the hydroelectricity will represent only 25% of the energy generated. Uruguay is the one that projects a greater participation of non-conventional renewables. The black dotted curve (negative values) indicates the expected value of turbine discharges. As can be seen, Uruguay in expected value will have 9% of turbine discharges and Brazil 7% of its total generation. Note that these percentages are equivalent to two or three years of growth in Demand for the systems.

The Fig.2 show the flows between Argentina and Brazil, according to month of the year for the assumed infrastructure to 2030 with a DELTA of exchanges of 60 US$/MWh (assumption made assuming that countries continue to export only turbineable discharges or thermal surpluses to replace variable cost resources, greater than or equal to 60 US$/MWh). (in the full paper the same graph is shown for the flows between Uruguay and Argentina and Brasl).

Conclusions

As can be seen, maintaining the restriction of not exchanging energy that affects the energy reservoirs, only exchanges are carried out at the extremes of 10% probability (in each direction). This then means that 80% of the time the interconnections will remain unused if an alternative is not sought that makes new exchange modalities viable.

In the full paper, a possible solution is detailed based on countries allowing deferred settlement spot exchanges. In practice, the energy from turbine discharges could be sent to a country with storage capacity and considered as generation of the plant that stores it. For the purposes of the country receiving the energy, the storage level would be considered unaffected, with the energy received being the first to be spilled if necessary. And if in the future, the energy can be placed in any of the markets, applying the existing trade restrictions, then at that moment the export price and the profit of the generator that carried out the temporary storage would be fixed. It is a solution where everyone wins.

Disclaimer

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