Flexibility of hydropower in Colombia to balance the growing share of intermittent renewables

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Overview

Variable renewable energies are changing today's energy sectors. Seeking a sustainable future, worldwide efforts are being made to reduce the carbon footprint of economic and energy systems in order to reduce climate impacts (Kerscher & Arboleya, 2022). To contribute to the reduction of polluting emissions from the electricity sector, countries have begun to adopt plans that include the integration of renewable energies and restrictions on generation with fossil fuels (Verástegui et al., 2021).

This growing participation of renewable energies in electricity markets has allowed them to become more independent of fossil resources. But the above makes the market more dependent on solar and wind generation, which depend on variable weather conditions to generate power, such as wind speed and solar radiation. This resources are intermittent and must be constantly monitored (Çiçek et al., 2021) and backed by trustable resources such as fossil fuels, storage or hydropower.

A high share of variable renewable energies in an electricity market requires flexibility to quickly respond to fluctuations of the renewable energy sources that generate intermittency in generation (Sasaki et al., 2022). We use stochastic optimization to prove that the large share of hydro-storage installed in Colombia can allow the introduction of large-scale wind and solar power without reliability risks. However, the current market design cannot guarantee that hydropower will be used in a way that minimizes the loss of load probability.

Methodology

We propose a stochastic optimization model to evaluate the effects on LOLP (Loss of load probability) of different scenarios of wind and solar penetration in the Colombian electricity market, assuming that only the currently installed hydropower capacity is in place – i.e., no thermal generation. The model considers the variability of wind, solar and water resources, and the available storage capacity of the hydro reservoirs.

Results

The simulations demonstrate that the currently installed hydropower capacity in the Colombian electricity market can provide enough flexibility to face the intermittency of the renewable energies, considering enough wind, and solar power to meet demand for at least the next 10 years. Depending on the mix of wind and solar, as well as their particular locations, the need for flexibility varies and the currently installed hydropower can become insufficient sooner or later.

Conclusions

With the energy transition to renewable energies, it is imperative to have enough flexibility in order to balance the system and guarantee security of supply. Renewable energies are steadily increasing, and they are expected to keep this growth over the years, as they grow their share in electricity markets the need for flexibility will grow with them as well.

We calculate the LOLP in the Colombian electricity market under different scenarios of wind and solar installation, considering only the currently installed hydropower capacity, and conclude that there is enough flexibility to support the growth of the system for the next 10 years. But, our conclusions are based on an optimal operation of the hydropower reservoirs, and achieving this will require market reforms in order to give the right signals or incentives for hydropower generators to behave according to the systems' interests.

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