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Climate change impacts and adaptation strategies for a hydro-dominated power system via stochastic optimization

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Abstract— As outlined in the Paris Agreement on climate change, efforts to mitigate and adapt to climate change will require new modes of development of the energy sector including the transformation and expansion of power systems to low-carbon and more resilient designs. However, there is a need for more systematic tools to support decision-making processes in the context of climate change impacts and adaptation strategies for the energy and power sectors. For instance, quantitative approaches should be developed and implemented for the assessment of the impacts and hedging strategies associated with the uncertainties inherent to energy and power planning problems. This study addresses the development and implementation of an integrated model-based system analysis, which uses general circulation models, global sensitivity analysis, and stochastic optimization techniques, for the optimal design and planning of the Colombian power system in view of submitted climate pledges and climate change adaptation. It was found that during the 2015 to 2029 time frame, climate change will likely reduce the capacity factor of hydropower generation by 5.5-17.1%. Additionally, it was established that the independent effects of three key uncertain parameters, i.e., capacity factor of hydropower generation, gas prices, and emission reduction target, account for ~96% of the variance in the total cost for the required expansion and operation of the power system. Furthermore, when uncertainty is taken into account, the optimal expansion strategy consists of rescheduling of investments in hydropower plants and investing more in carbon management technologies and renewable power plants to compensate for the uncertainty in hydropower generation, climate policy, and gas prices.

Index Terms— Climate change; Adaptation strategies; Hydro-dominated; Power system; Stochastic optimization

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