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A probabilistic and value-based planning approach to assess the competitiveness between gas-fired and renewables in hydro-dominated systems: a Brazilian case study

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Abstract-

**The main challenge with the penetration of variable renewable energy (VRE) in thermal-dominated systems has been the increase in the need for operating reserves, relying on dispatchable and flexible resources. In the case of hydro-dominated systems, the cost-effective flexibility provided by hydro-plants facilitates the penetration of VRE, but the compounded production variability of these resources challenges the integration of baseload gas-fired plants. The Brazilian power system illustrates this situation, in which the development of large associated gas fields economically depends on the operation of gas-fired plants. Given the current competitiveness of VRE, a natural question is the economic value and tradeoffs for expanding the system opting between baseload gas-fired generation and VRE in an already flexible hydropower system. This paper presents a methodology based on a multi-stage and stochastic capacity expansion model to estimate the optimal mix of baseload thermal power plants and VRE additions considering their contributions for security of supply, which includes peak, energy, and operating reserves, which are endogenously defined in a time-varying and sized in a dynamic way as well as adequacy constraints. The presented model calculates the optimal decision plan, allowing for the estimation of the economical tradeoffs between baseload gas and VRE supply considering their value for the required services to the system. This allows for a comparison between the integration costs of these technologies on the same basis, thus helping policymakers and system planners to better decide on the best way to integrate the gas resources in an electricity industry increasingly renewable. A case study based on a real industrial application is presented for the Brazilian power system. **

Index Terms- power system expansion; co-optimization of energy and reserve; associated natural gas; multi-stage stochastic programming; electricity-gas integration

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