Optimal joint energy and secondary regulation reserve hourly scheduling of variable speed pumped storage hydropower plants

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Abstract— This paper presents a mixed integer linear programming model for the hourly energy and secondary regulation reserve scheduling of a price-taker and closed-loop variable speed pumped-storage hydropower plant, considering the energy losses due to the use of electronic frequency converters. The plant participates in the day-ahead energy market and in the secondary regulation service of the Iberian electric power system. The model is utilised to compare the income of the plant with and without considering the variable speed technology, with synchronous or asynchronous machines, with and without bypassing the frequency converter in generating mode, and with and without perfect information of the electric power system data. Numerical testing results demonstrate that the operation with the variable speed technology could help notably to enlarge the income of the power plant and that the secondary regulation reserve market might be the main source of revenue for the power plant.

Index Terms— Pumped Storage Plant, Secondary Regulation Service, Variable Speed Technology, Risk Aversion, Scenario-based Approach.

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