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# Stochastic optimization model for the weekly scheduling of a hydropower system in day-ahead and secondary regulation reserve markets

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**Abstract-**

**Hydropower stands out for its fast response ability and flexible operation, playing a predominant role in the provision of regulation reserves. As hydro power is an energy-constrained generation technology, it needs to be protected against any possible deployment of the scheduled reserves. However, the few models that formulate a detailed hourly co-optimization of energy and regulation reserves, neglect infeasibilities that could be derived from the requested reserves in real-time. As the regulation reserve market is becoming increasingly important, hydro producers can no longer neglect such effect. This paper presents a stochastic optimization model to find the optimal hourly schedule of a set of hydraulically coupled hydropower plants to obtain the weekly operation that simultaneously maximizes the expected profit in both energy and regulation reserves markets. The model is formulated for a price-taker agent, and it considers a very detailed representation of the system including minimum-maximum water flows, net head dependency, and fractional water travel time. The main contribution is that the obtained solution protects a multi-reservoir system against risk of water and storage unavailability due to the uncertainty in real-time use of regulation-up and down reserves, respectively, and that the reserves deem the net head dependency. The paper presents a realistic case study where the proposed formulation has been tested successfully with real data from the Spanish electricity market.**

**Index Terms- Day-ahead electricity market; Secondary regulation reserve market; Stochastic programming; Cascaded reservoir system**



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