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A Novel Framework for Hydropower Scheduling Under Uncertainty

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Although there have been numerous advances in production cost modeling techniques over past decade, the characterization of hydropower operations has remained relatively unsophisticated in common usage, largely ignoring the water-energy nexus. We believe that there are two key reasons for this simple representation. First, hydropower operational constraint data (including technical constraints, water-use priorities and rules, environmental constraints, and drought mitigation plans) are often not readily available or easily expressed in the Mixed Integer Linear Programming (MILP) problems that represent unit commitment and economic dispatch of generating assets. Second, the water availability uncertainties involved in hydropower planning often span many days, months, or even years. These uncertainties do not align well with the day-ahead unit commitment problem that is solved for grid operations. This makes it difficult for unit commitment models to comprehensively include and make best use of water and hydropower production.

Recent trends toward increased reliance on variable generation and emerging concerns about the impacts of climate and weather uncertainty on infrastructure systems have highlighted the growing need for improved hydropower modeling capabilities within grid operations models. To address this challenge, the United States Department of Energy's National Renewable Energy Laboratory (NREL) is working with RTI International to develop an open-source modeling platform that enables the flexible specification of power system scheduling problems, including enhanced representation of water resource availability, hydropower constraints, and multi-stage stochastic programming capabilities. The platform combines the flexibility of NREL's Scalable Integrated Infrastructure Planning (SIIP) grid operations model with a generalized river basin decision support system and network flow model (MODSIM-DSS), allowing optimization across both grid and river basin operations. Our work will leverage this novel framework to explore emerging approaches to scheduling hydropower under uncertainty at time scales raging from minutes to decades. Demonstration use cases focus on research and enhanced planning in the water-energy nexus domain, including how to predict and make best use of water availability for hydropower production, discover tradeoffs between water supply and hydropower generation, and how to predict and quantify the space-time dependencies and feedback connections between variable generation (wind and solar), the water cycle and other weather-related events, and hydropower.