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Strategies for reducing conflict in water-energy systems – Filling new large reservoirs on the Nile

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Hydropower systems can have unacceptably low performance and high downstream impacts during low flow events. In growing systems with existing downstream water uses, the highest impacts can be during filling of new large reservoirs, which can last several years. Slower filling of new dams can minimize negative effects but will delay their benefits. Conflict can arise between upstream and downstream users regarding how quickly the dams should be filled and will be exacerbated if drought occurs during this period. We develop an operating strategy that responds to flows accrued during the reservoir filling period helping to balance the trade-offs between the impacts of filling and releasing. The method is applied to assess possible filling strategies for the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile. Given variability of the Blue Nile River, how quickly the 72 BCM storage capacity reservoir (150% the annual river flow) can be filled and its downstream impact is subject to uncertainty. Ethiopia also plans to generate electricity during the dam's filling period to alleviate the chronic shortage of energy in the country. This work aims to quantify the performance trade-offs associated with different Pareto-optimal operating strategies in the filling period. We apply a heuristic optimization approach to derive multi-year efficient standard and adaptive reservoir operating (filling) strategies. We use many objective optimization and visual analytics to present the efficient performance trade-offs among the conflicting goals of maximizing revenue from the dam and benefits accrued through downstream releases during the filling period. Results show adaptive filling can achieve higher performance (i.e. higher upstream benefits during average and above average flow conditions while also avoiding adverse downstream impacts under low flow conditions) compared to static storage based filling rules.