HYDROELECTRIC MANAGEMENT FOR PEAK-DEMAND ENERGY: BALANCING INTERMITTENT RENEWABLE GENERATION IN THE U.S. GRID

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Overview

Over past decades, ecological concerns have reduced the production of peak-demand energy from hydroelectric plants. Over the same period, as U.S. power markets incorporate solar and wind generation, the demand for flexible, quick-ramping energy during evening hours is increasing. Peak energy needs in excess of baseload are largely covered by flexible natural gas generation. As more intermittent renewables are integrated into the grid, demand for alternative sources of peak power generation will increase.

Dynamic modeling of dams and rivers can illuminate economic and environmental tradeoffs as decision-makers attempt to optimize the value of river flows. This paper models the first- and second-order impacts of a small reservoir-dam-river system and applies this framework to an existing Bureau of Reclamation dam and generator in the upper Rio Grande basin. A system dynamics model of the dam allows a cost-benefit analysis of dispatchable energy production in the presence of constraining daily, weekly or monthly flow requirements. The results provide a scalable framework for incorporating the flexibility value of hydroelectric power into the cost-benefit analysis that drives maintenance, upgrade and decommissioning decisions for existing U.S. hydroelectric dams.

Methods

System dynamics modelling, benefit transfer from contingent valuation studies, dynamic optimization

Results

Preliminary results suggest that the non-market ecological value of supporting increased solar and wind generation on the larger grid provide a significant benefit to the public which has not been adequately assessed in previous cost-benefit analyses. In the case study, limited flow adjustment over the course of the day can significantly increase the value of hydroelectric power generated without significant ecological impact.

Conclusions

Hydroelectric power, while non-carbon-producing, can have substantial environmental impact. Economic modelling of market and non-market values associated with a river and reservoir system permits optimization of hydroelectric power to complement intermittent renewables without sacrificing ecological goals. The case study suggests that permitting constrained economical dispatch of existing small hydropower generators currently functioning as run-of-river production may be optimal from an ecological as well as economic point of view.